DISSERTATION ON

PREOPERATIVE RADIOLOGICAL ASSESSMENT OF TEMPORAL BONE IN PATIENTS UNDERGOING COCHLEAR IMPLANTS AND CORRELATE WITH INTRAOPERATIVE FINDINGS- REVIEW EFFICACY OF RADIOLOGY

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERDITY

With partial fulfillment of the regulations

For the award of the degree of

MASTER OF SURGERY - OTORHINOLARYNGOLOGY

BRANCH - IV

UPGRADED INSTITUE OF OTORHINOLARYNGOLOGY

MADRAS MEDICAL COLLEGE

CHENNAI

APRIL 2015

BONAFIDE CERTIFICATE

This is to certify that this dissertation is a bonafide record of work done by Dr.P.Sengottuvelu on "**PREOPERATIVE RADIOLOGICAL ASSESSMENT OF TEMPORAL BONE IN PATIENTS UNDERGOING COCHLEAR IMPLANTS AND CORRELATE WITH INTRAOPERATIVE FINDINGS-REVIEW EFFICACY OF RADIOLOGY**", during his M.S. ENT course from July 2013 to April 2015 at the Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai. He is appearing for his M.S. Branch – IV Degree Examination in April – 2015 and his work has been done with partial fulfillment of the regulations of The TamilNadu Dr. M.G.R Medical University, Chennai. I forward this to The TamilNadu Dr. M.G. R Medical University, Chennai, TamilNadu, India.

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CERTIFICATE

This is to certify that this dissertation titled "**Preoperative Radiological Assessment Of Temporal Bone in Patients Undergoing Cochlear Implants And Correlate With Intraoperative Findings-Review Efficacy Of Radiology"** been carried out independently and satisfactorily by Dr.P.SENGOTTUVELU, in Institute Of Otorhinolaryngology, Madras Medical College and Rajiv Gandhi General Hospital, Chennai under my supervision and guidance. All the case studies, results and observations and their interpretation of the thesis has been done by the candidate and periodically checked by me. He is appearing for his M.S.ENT branch IV degree examination in April 2015 and his work has been done with partial fulfillment of the regulations of The Tamilnadu Dr.M.G.R Medical University, Chennai, Tamilnadu, India.

Prof.Dr.R.Muthukumar, MS, DLO, DNB.

Place: Chennai
Date :

DECLARATION

I, **Dr. P.Sengottuvelu**, solemnly declare that this dissertation entitled **"Preoperative Radiological Assessment Of Temporal Bone in Patients Undergoing Cochlear Implants And Correlate With Intraoperative Findings-Review Efficacy Of Radiology"** is a bonafide work done by me in Upgraded Institute of Otorhinolaryngology, Madras Medical College and Rajiv Gandhi General Hospital, Chennai during the period of 2012 to 2015 under the guidance of **Prof.Dr.R.Muthukumar, M.S., D.L.O., DNB.** Professor, Institute Of Otorhinolaryngology, Madras Medical College and Rajiv Gandhi General Hospital, Chennai – 3 and submitted to The Tamilnadu Dr. MGR Medical University, Guindy, Chennai – 32 in the partial fulfillment of the regulations for the award of the M.S.E.N.T., (Branch IV)

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I must first and foremost thank my guide and Professor **Dr.R.Muthukumar** for having pushed me to take up interest in cochlear implantation. I also thank **Prof.Dr.G.Gananathan, Prof.Dr.M.K.Rajasekar, Prof.Dr.G.Selvarajan** and Prof. **Dr.Sankaranarayanan** for their support and encouragement.

I also thank my Assistant Professors **Dr M.Gowrishankar, Dr. Thalapathy Ramkumar, Dr.Venugopal and Dr.Vikram** for their valuable directions in shaping up this study.

I owe my thanks to my Fellow Post Graduates especially Dr.P.Thomas and Staff.

Finally, I like to thank my wife and children for their support.

CONTENTS

ABBREVIATIONS

HRCT	-	High Resolution Compurized Tomography
MRI	-	Magnetic Resonance Imaging
SNHL	-	Sensory Neural Hearing Loss
PTA	-	Pure Tone Audiometry
BOA	-	Behavioural Observation Audiometry
BERA	-	Brainstem Evoked Response Audiometry
OAES	-	Oto Acoustic Emissions
EAS	-	Electircal Acoustic stimulation

INTRODUCTION

Congenital sensorineural hearing loss is one of the most common birth defects with the incidence of 1: 1000 live births in India. Cochlear implantation is the method of choice in children with severe to profound sensorineural hearing loss. Imaging is required to properly evaluate these cases for any anatomical anomalies, especially in the prelingual deaf children. Both high resolution computerized tomography and magnetic resonance imaging prove to be important diagnostic modalities in patients to undergo cochlear implant. Both has its own advantages and disadvantages. The high resolution computerized tomography can detect anatomical malformations of the bony inner ear, while the magnetic resonance imaging provide detail about the membranous labyrinth and the status of the vestibulocochlear nerve.

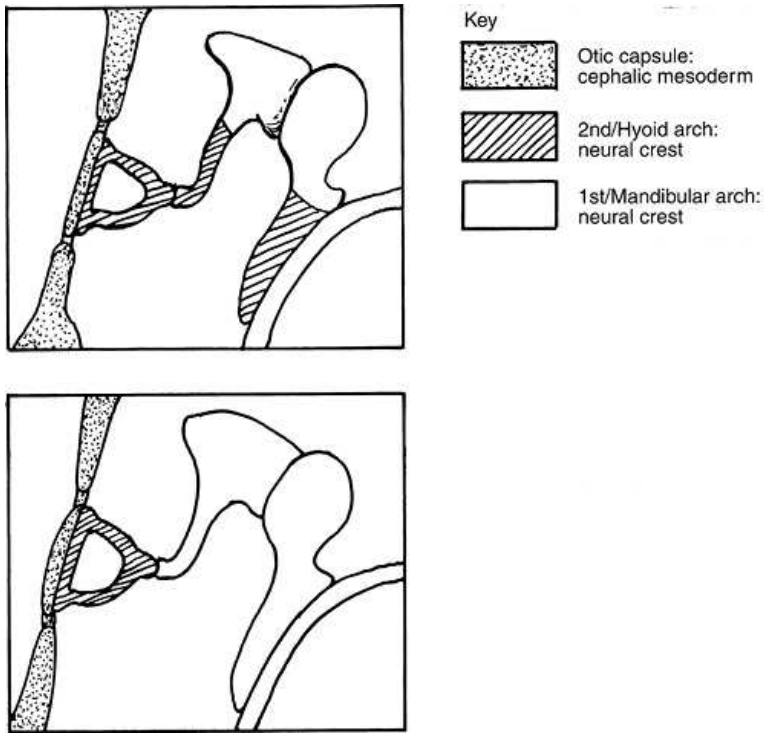
Bony inner ear malformations are fairly uncommon, accounting for 20 % of sensorineural hearing loss, while anomalies of the membranous labyrinth account for approximately 80 % of the cases. There has been a debate to which modality serves a better purpose in evaluating patients undergoing cochlear implantation. Accurate preoperative imaging is required for candidate selection,

identification of suitable ear for cochlear implantation and selection of appropriate device. Proper surgical planning must involve careful review of sectional images, to anticipate potential complications and their management.

ANATOMY, DEVELOPEMENT AND PHYSIOLOGY

Development of ossicles

The main origin of ossicles is the neural crest mesenchyme of the first and second branchial arches, the meckel cartilage- first arch and the reichart cartilage- second arch. The head of the malleus and the body and short process of incus are formed from the meckel cartilage. The mandibular branch of the trigeminal nerve supplies the first arch. The long process of the incus, handle of the malleus, stapes suprastructure and tympanic surface of the stapes footplate are derived from the reichart cartilage. The facial nerve is the nerve of the second arch. The stapes footplate develops from otic capsule. The malleus and incus form at sixth week of gestation and ossification completes by 30th week. The stapes appears slightly before malleus and incus and completes ossification at 16 weeks.

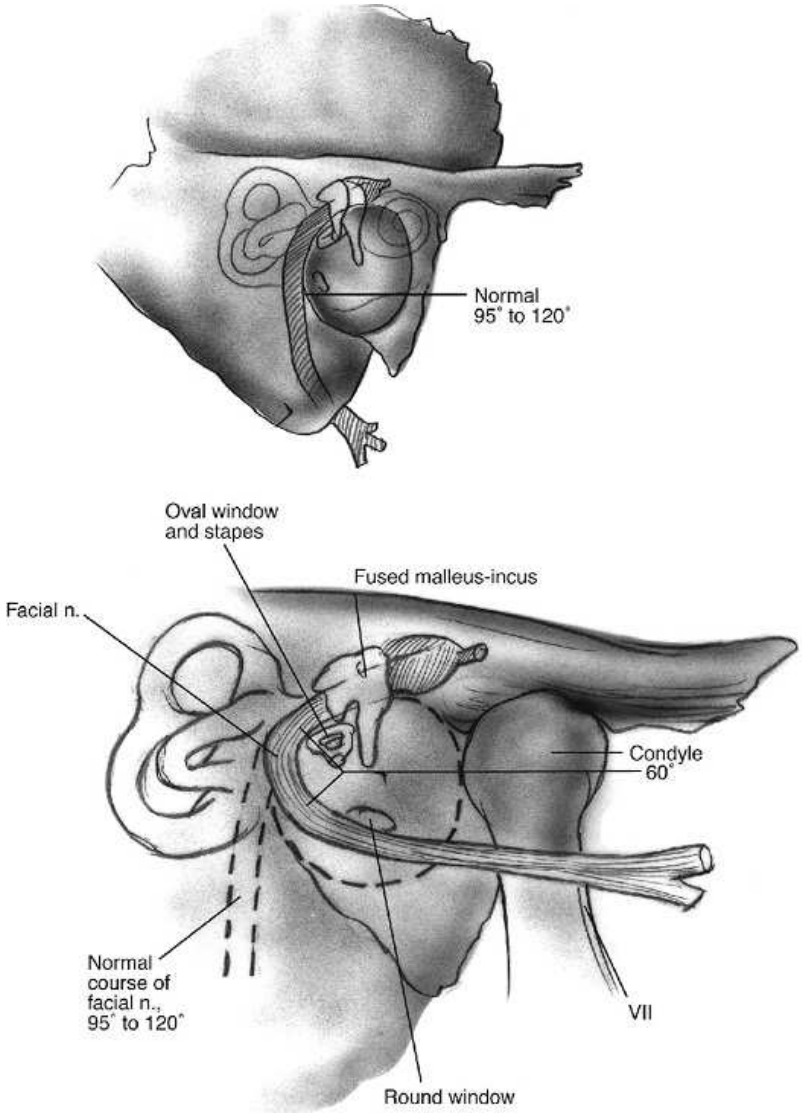


OSSICULAR DEVELOPEMENT

Development of the facial nerve

The facioacoustic primordium appears in the third week of gestation and split into seventh and eighth cranial nerves by the fifth week. Secretomotor and special sensation from the nervus intermedius develop by the seventh week. The chorda tympani appear by the fourth week. The greater superficial petrosal nerve appears in the sixth week, the nerve to the stapedius is identifiable by the seventh week. The first genu is formed due to the nerve being pushed forward by the otic capsule. The fallopian canal is formed partly by the reichart cartilage. By 26th week, partial closure of the fallopian canal by bone is found. As a result of the

nerve being pushed posteriorly by the developing structures, the facial nerve comes to lie between the tympanic and mastoid portions of the temporal bone.



DEVELOPMENT OF FACIAL NERVE

VERTICAL SEGMENT OF FACIAL NERVE

DEVELOPMENT OF COCHLEA

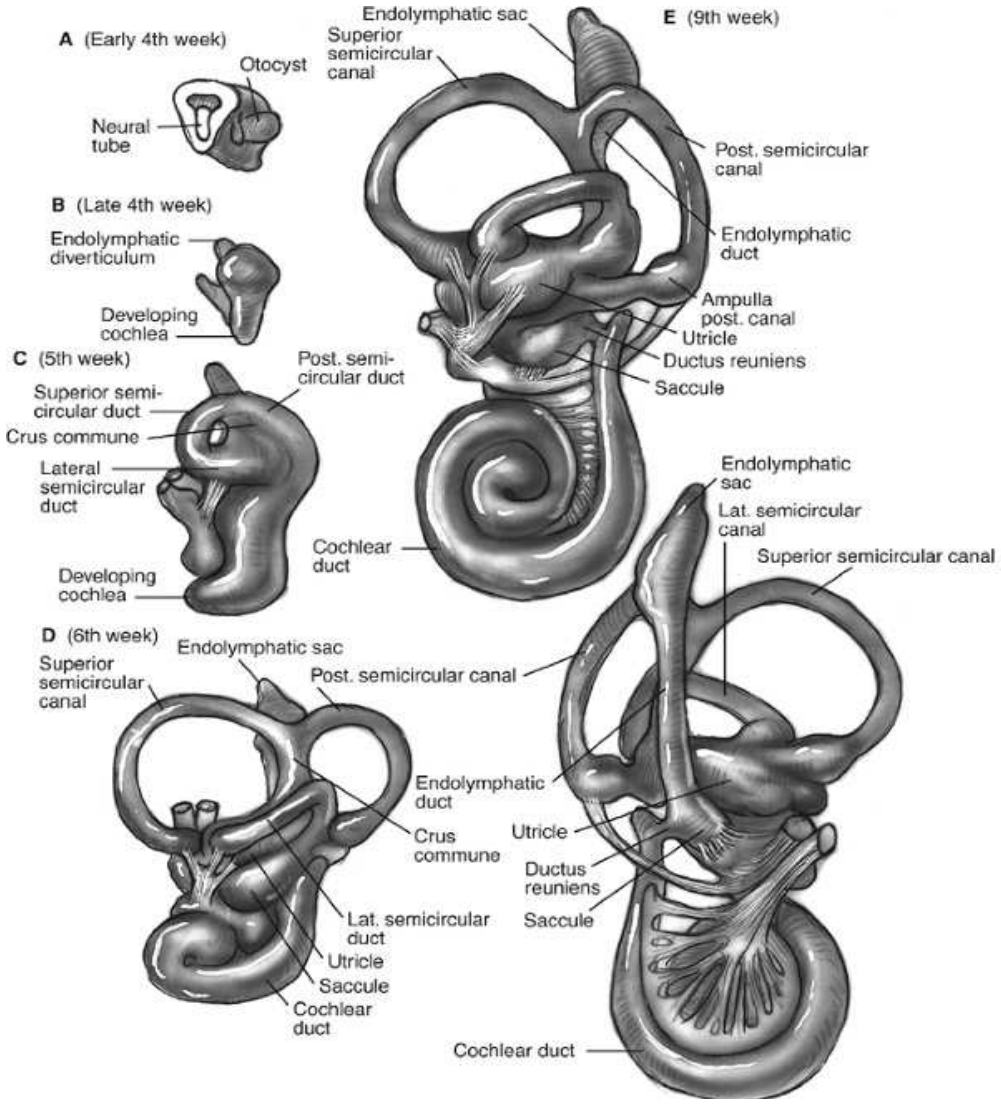
At the end of the third week of gestation, the otic placode can be differentiated on the lateral surface of the cephalic end of the embryo as a thickening of the ectoderm in contact with hindbrain portion of the closing neural tube. The placode invaginates itself to become a pit and a closed sac, the otocyst or otic vesicle, the precursor of the membranous labyrinth. The cranial portion

becomes the developing endolymphatic duct. The caudal portion becomes the cochlear duct, and the intermediate portion, the utriculosaccular area is the vestibular precursor. From the utricular part of the vestibular pouch, three outpocketings appear, which are converted, through fusion of the central epithelium, into semicircular canals. The utricle and saccule start to develop in the sixth week from the utriculosaccular duct. The cochlear duct also begins to grow from the saccule in the sixth week. The cochlear duct grows rapidly, having 1.5 turns at 8th weeks and the full 2.5turns at 10 weeks, although it does not reach full length until 20 weeks.

The sensory epithelium of the cochlea begins to develop in the seventh week as the duct itself grows and begins to coil. Lying on the medial wall, the layers of the epithelium organize into two ridges and spiral along the length of the cochlea. The larger inner ridge differentiates into the inner hair cells and tectorial membrane. The smaller outer ridge differentiates into the outer hair cells. The supporting cells arise from both ridges. Starts at 11th week and completes by 21st week.

In the eigth week of gestation, the vascular precartilage that surrounds the membranous labyrinth developes vacuoles in its

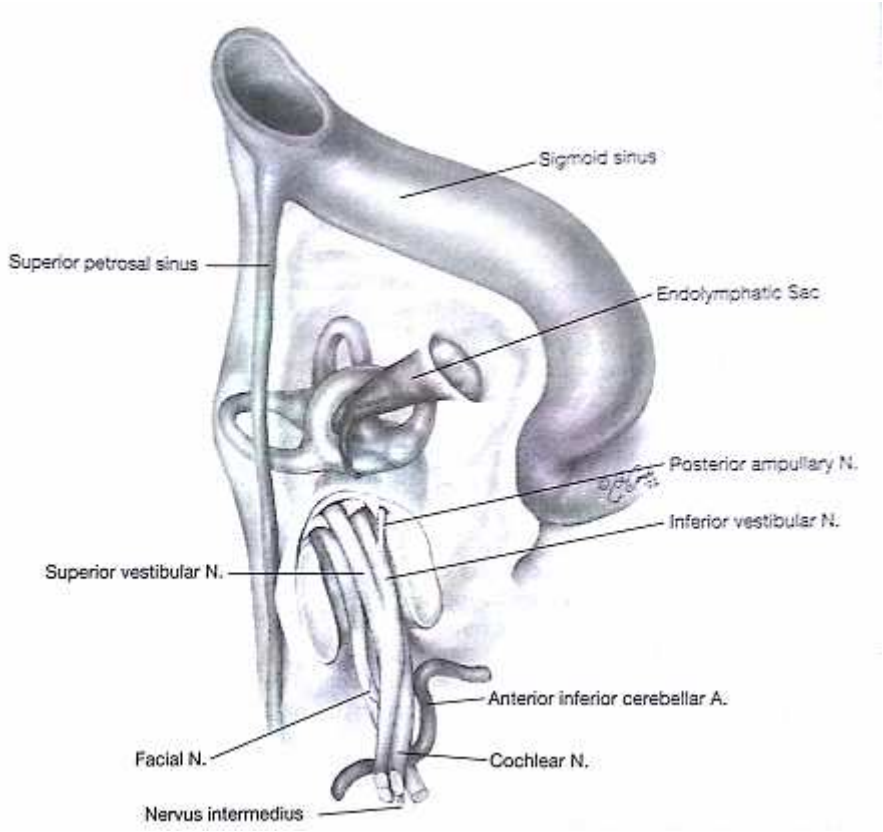
structure that coalesce to leave the perilymphatic space. The perilymphatic space is completes by week 24.



DEVELOPMENT OF COCHLEA

DEVELOPMENT OF VESTIBULOCOCHLEAR NERVE

The vestibulocochlear ganglia arise from the ectoderm of the primitive otocyst, having split away from the epithelium in the third week. While the otocyst is dividing into its vestibular and cochlear portions, the vestibulocochlear ganglion divides into a superior and an inferior division. The fibres of the superior division pass to innervate the superior and lateral ampullae of the semicircular canal and the utricle. The inferior division sends firbres to the posterior ampulla and the saccule. The remaining portion becomes the spiral ganglion of the cochlea. At ninth week, nerve fibres grow to enter the sensory epithelium, and synaptic connections are identifiable as the hair cells begin to differentiate in week 11.

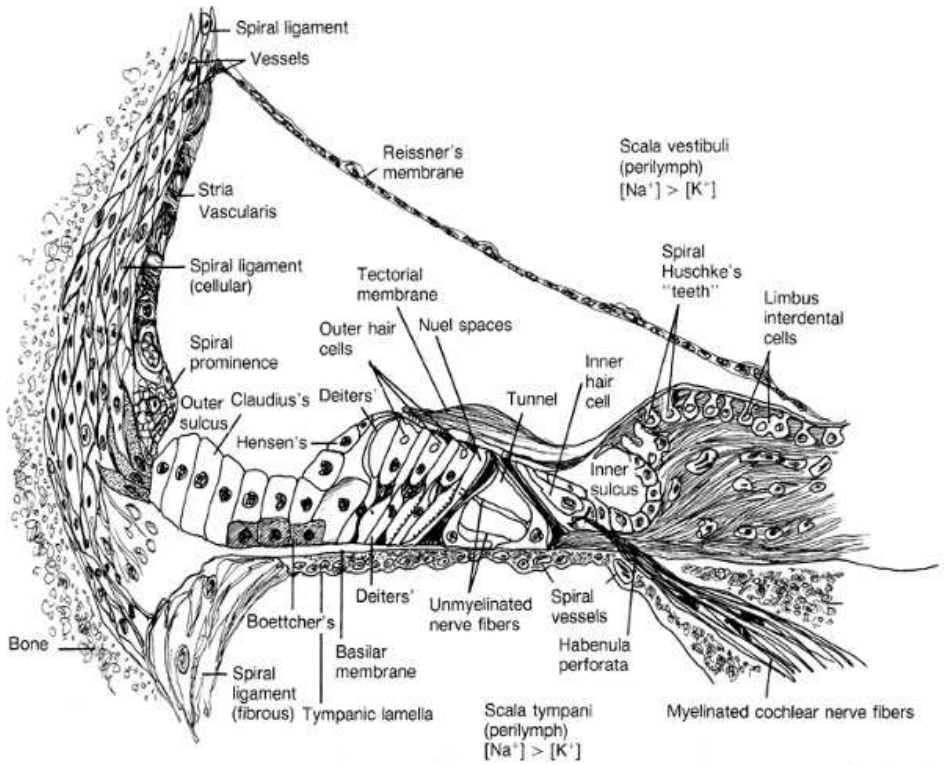


ROTATION OF FACIAL, COHCLEAR AND VESTIBULAR NERVES IN IAC

ANATOMY AND PHYSIOLOGY OF THE COCHLEA

The human cochlea is a coiled, bony tube approximately 32 mm long, which is divided into three parts namely, the scala vestibuli, scala media, and scala tympani. The scalae vestibuli and tympani contain perilymph, an extracellular fluid-like material with a potassium concentration of 4 mEq/L and a sodium concentration of 139 mEq/L. The scala media is bounded by the Reissner membrane, the basilar membrane and osseous spiral lamina, and the lateral wall. It contains endolymph, an intracellular-like fluid with a potassium concentration of 144 mEq/L and a sodium concentration of 13 mEq/L. The scala media has a positive direct current (DC) resting potential of approximately 80 mV that decreases slightly from base to apex. This endocochlear potential is produced by the stria vascularis of the cochlea. The sodium-potassium adenosine triphosphatase (Na+-K+-ATPase) pumps in a number of specialized cells of the stria vascularis contribute to this potential. Acoustic energy enters the cochlea through the piston-like action of the stapes footplate on the oval window and is coupled directly to the perilymph of the scala vestibuli. The perilymph of the scala vestibuli communicates with the perilymph of the scala tympani

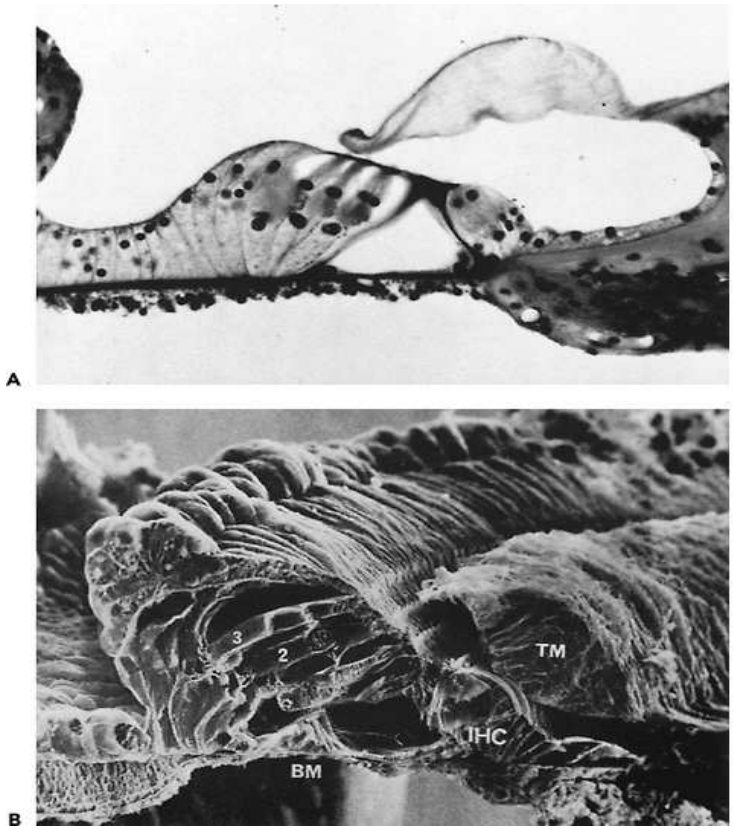
through a small opening at the apex of the cochlea known as the helicotrema. The organ of Corti located in basilar membrane and spiral lamina. The basilar membrane is approximately 0.12 mm wide at the base and increases to approximately 0.5 mm at the apex. The major components of the organ of Corti are the outer and inner hair cells, supporting cells (Deiters, Hensen, Claudius), tectorial membrane, and the reticular laminae cuticular plate complex. Supporting cells provide structural and metabolic support for the organ of Corti.



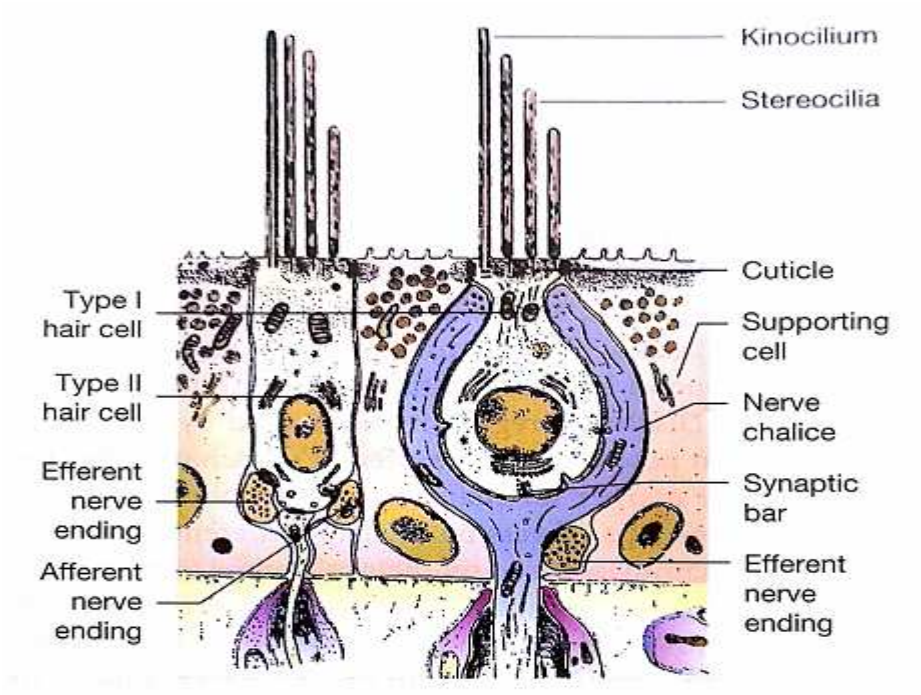
ANATOMY OF COCHLEA

The phalangeal processes of the Deiters cells form tight cell junctions of the reticular lamina. The spiral ganglion, auditory nerve sends axons to the cochlear nucleus, whereas the dendrite projects through the osseous spiral lamina. Of the 50,000 neurons that innervate the cochlea, 90% to 95% synapse directly on inner hair cells. These are called type I neurons. Each inner hair cell is innervated by approximately 15 to 20 type I neurons. In contrast, 5% to 10% of the 50,000 neurons innervate the outer hair cells (type II neurons). Each type II neuron branches to innervate approximately 10 outer hair cells. In addition to the afferent innervation pattern of the cochlea, approximately 1,800 efferent fibers, originating from the ipsilateral and contralateral superior olivary complex, project to the cochlea. Transduction is initiated by displacement of the basilar membrane in response to displacement of the stapes due to acoustic energy. Travelling wave produces displacement pattern on the basilar membrane. The basilar membrane is stiffer at the base than in the apex. The stiffness component is distributed continuously. Therefore, the traveling wave always progresses from base to apex. Traveling waves produced by high-frequency sounds (10 kHz) have maximal displacement near the base of the cochlea, whereas the waves to

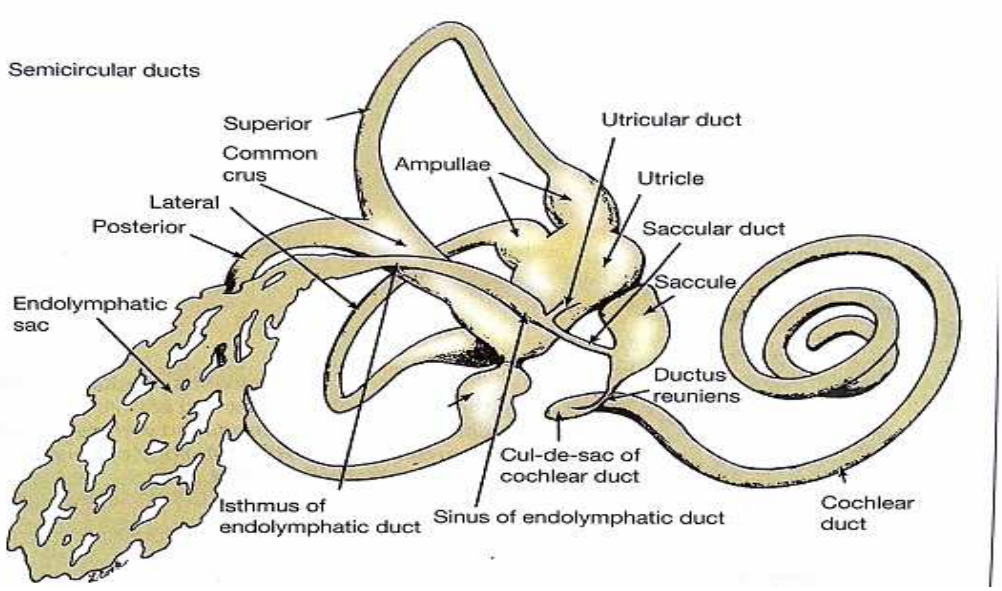
low-frequency sounds (125 Hz) have the maximum toward the apical region. Traveling waves generated by high-frequency sounds do not reach the apical region of the cochlea, whereas waves to low-frequency sounds can travel the entire length of the basilar membrane. In the past, the mechanical traveling wave was considered a broadly tuned response, with finer tuning introduced subsequently by transduction, the auditory nerve, and the CNS.



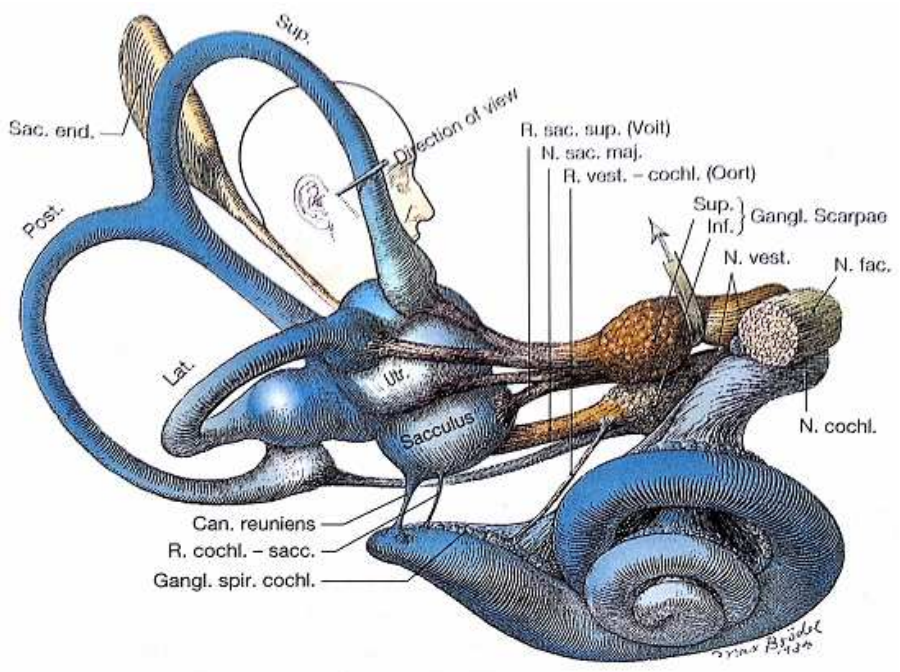
HAIR CELLS



TYPE 1 & 2 SENSORY EPITHELIUM

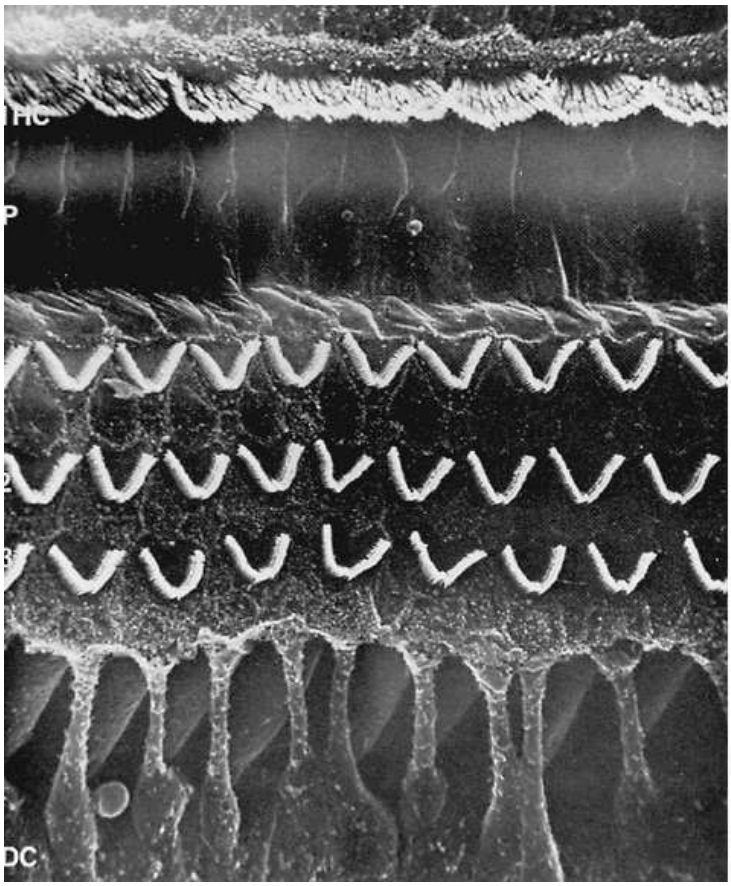


MEMBRANOUS LABYRINTH



Deflection of the stereocilia by the traveling wave opens and closes nonspecific ion channels at the tips of the stereocilia, resulting in current flow (potassium) into the sensory cell. The flow of potassium ions into the sensory cell is modulated by the opening and closing of ion channels of the stereocilia. The potassium flux is caused by the endocochlear potential of +80 mV added to the negative intracellular potentials of hair cells. The resulting intracellular depolarization causes an enzyme cascade involving calcium. This ultimately leads to the release of chemical transmitters, and the subsequent activation of the afferent nerve fibers. When a short-duration signal is presented to the ear, an echo emanating from the cochlea can be recorded in the external auditory meatus. This phenomenon is known as otoacoustic emissions.

Glutamate has been detected in both spiral ganglion cells and sensory cells. The principal transmitter substance of cochlear efferent fibers is acetylcholine.



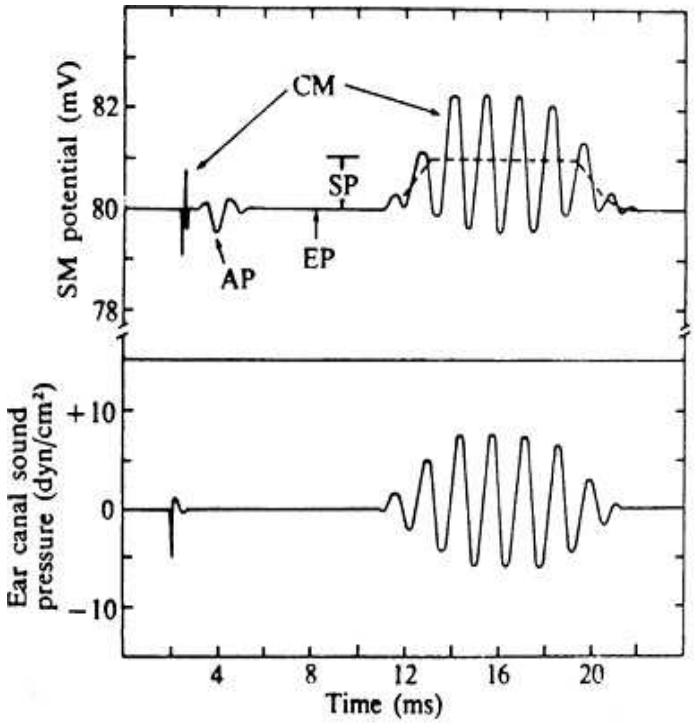
PIEZOELECTRIC MEMBRANE

Four gross (extracellular) potentials can be recorded in the cochlea, endolymphatic (endocochlear) potential, cochlear microphonic, summating potential, and whole-nerve action potential. Endolymphatic potential is a DC potential of 80 to 100 mV recorded in the scala media. It arises from the stria vascularis of the lateral wall of the cochlea. The cochlear microphonic is an

alternating current (AC) voltage usually recorded within the cochlea or near the round window. It represents the potassium ion current flow through mainly the outer hair cells; that is, the electrical resistance of outer hair cells is altered by the motion of the basilar membrane. The corresponding voltage fluctuations, the cochlear microphonic, depend on the presence of outer hair cells. Unlike neural potentials, the waveform of the cochlear microphonic mirrors the motion of the basilar membrane. The summating potential is a DC potential recorded in the cochlea in response to sound. The whole-nerve or compound action potential arises from the all-or-none discharge of auditory nerve fibers.

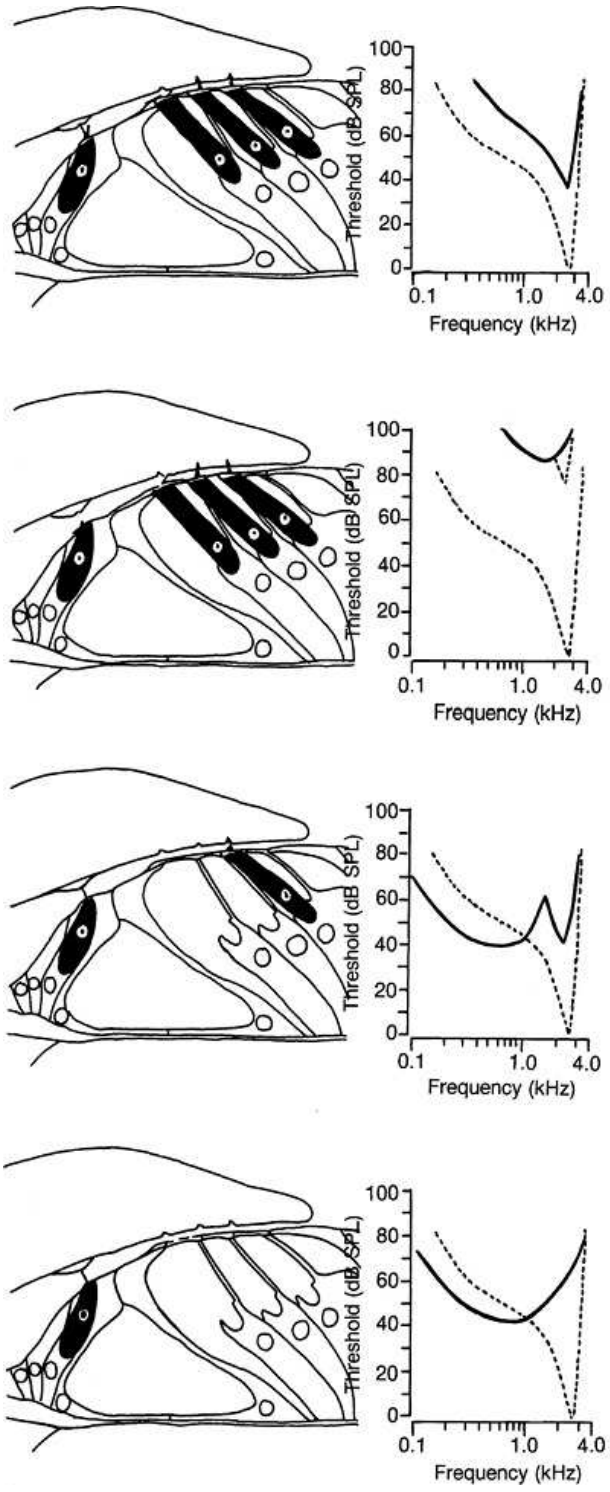
The auditory nerve has approximately 30,000 fibers in humans. 90% to 95% of neurons (type I, radial fibers) innervate inner hair cells, whereas 5% to 10% (type II, outer spiral fibers) innervate to the outer hair cells. The most basic measures of auditory nerve function are spontaneous rates, tuning curves, and intensity (rate-level) functions. The nerve fibers have been classified into three categories on the basis of rate of spontaneous discharge high (18 to 120 spikes per second), medium (0.5 to 18 spikes per second), and low (0 to 0.5 spikes per second). Fibers with high rates of spontaneous activity respond to auditory signals

at lower levels than do fibers with medium or low rates of spontaneous activity. The tuning curve of a single auditory nerve fiber is perhaps the most basic measure of auditory nerve function. A tone burst controlled in frequency and level is presented. The level is adjusted until a criterion change (one or two spikes per second) in firing rate is detected. Tone bursts covering a wide range of frequencies are used, and the lowest level of signal is recorded for a given frequency that produces a specific rate of discharge. The resulting isoresponse curve is called a tuning curve.



COCHLEAR POTENTIAL

Otoacoustic emissions (OAEs) are sounds that are detected in the ear canal when the tympanum receives vibrations transmitted through the middle ear from the cochlea. OAEs provide support for the notion that the cochlea is not just a passive receiver of acoustic energy but can also generate or amplify sounds. Spontaneous OAEs occur in the absence of acoustic stimulation and are typically highly stable pure tones of -10 to 30 dB SPL, which are found in 30% to 40% of healthy young ears. A second class of OAEs are produced after exposure to an acoustic signal. Transient-evoked OAEs (TEOAE) are made via a probe placed in the ear canal. The oscillatory sound pressure waveform seen in TEOAE responses actually corresponds to the motion of the eardrum resulting from pressure fluctuations generated within the cochlea. Although stimulatory clicks excite the entire cochlea, TEOAE responses can be used to give frequency-specific information about the cochlea through splitting of the responses into different frequency bands. TEOAEs are highly sensitive to cochlear pathology in frequency-specific manner. Distortion-product OAEs also are used widely in clinical situations. The TEOAE and DPOAE techniques complement each other.


100
80
60
40
20
0
Threshold (dB SPL)
0.1
1.0
4.0
Frequency (kHz)

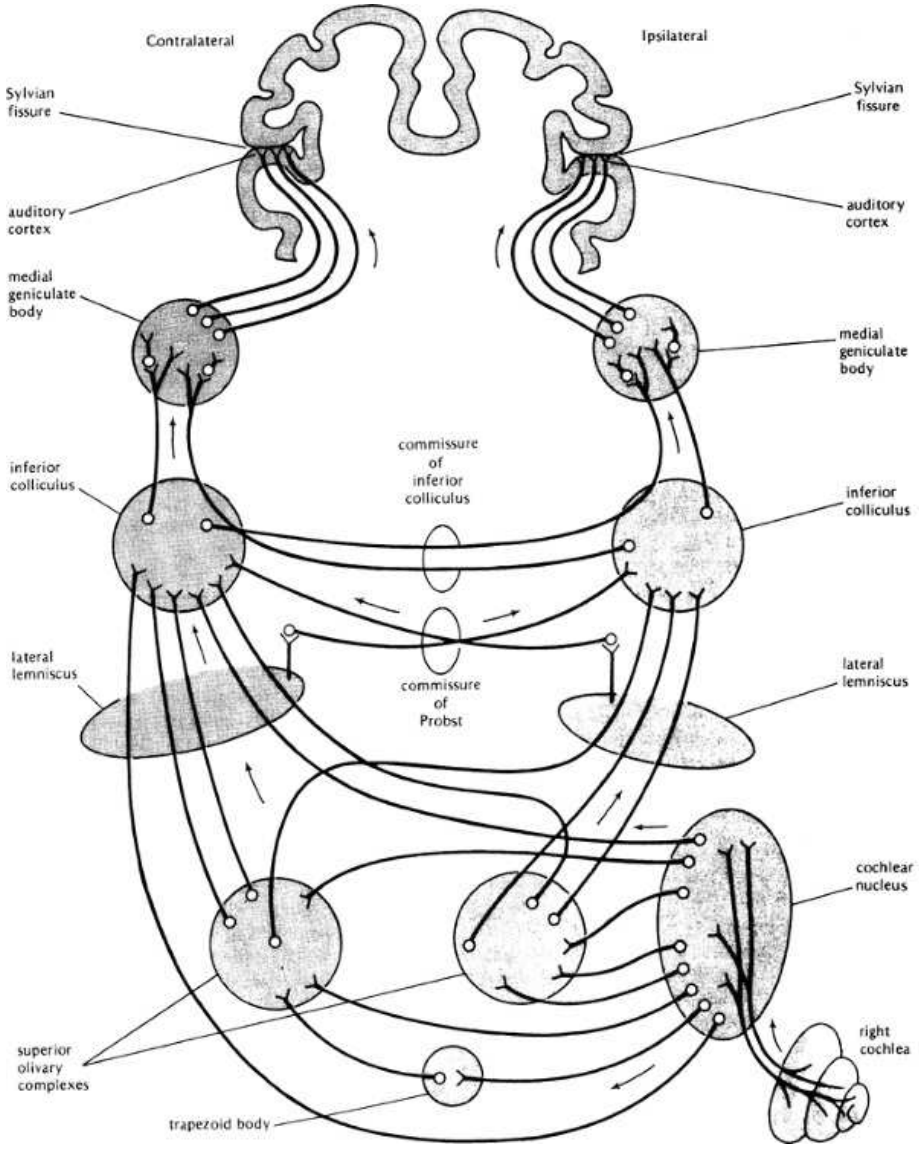
AUDITORY CENTRAL NERVOUS SYSTEM

The ascending and descending auditory pathways are described briefly herein in relation to auditory evoked potentials. All eighth-nerve afferent fibers stop at the level of the cochlear nucleus. Five major cell types are found within the cochlear nucleus, each with distinct cell morphologic and physiologic features, such as response to stimulus onset, stimulus offset, and frequency modulation. From the cochlear nucleus, most fibers cross the brainstem to the contralateral superior olivary complex; a much smaller number of fibers run to the ipsilateral superior olivary complex. The superior olivary complex is considered the first center in the ascending auditory system, where inputs from both ears converge. Auditory nuclei above the superior olivary complex can be excitatory or inhibitory with inputs from each ear. Stimulation of the contralateral ear typically is excitatory to cell bodies of the auditory CNS, whereas stimulation of the ipsilateral ear is inhibitory. the medial superior olivary complex is the origin of the crossed efferent fibers that terminate on outer hair cells, whereas the lateral superior olivary complex is the origin for the uncrossed efferent fibers that terminate on inner hair cells. The inferior colliculus is a complex nucleus with at least 18 major cell types and at least five areas of specialization. It is involved in

probably all forms of auditory behavior, including differential sensitivity for frequency and intensity, loudness, and binaural hearing. The inferior colliculus is clearly more than a relay center. The medial geniculate body of the thalamus sends projections to the auditory cortex, but its specific functions are unknown.

The auditory cortex is located in the sylvian fissure of the temporal lobe; many secondary auditory areas are clustered around the primary area. In each area, the cells are tonotopically organized in a columnar manner, each column having a special attribute. The cells in one column can have different tuning at a similar characteristic frequency, whereas another column can be associated with intensity encoding, another with providing inhibitory responses to stimulation of one ear and excitatory responses of the other ear, and so on. As is common for thalamic connections with the cortex, nuclei within the medial geniculate body that send fibers to the auditory cortex also receive fibers from the same area of the cortex. Bilateral lesions of the temporal lobe have been shown to produce wide-ranging effects (cortical deafness, in which several auditory behaviors are severely affected, including speech discrimination, localization of sound, temporal processing of information, and the detection of faint, short-duration signals).

Another important feature of the auditory system is its tonotopic nature. From the basilar membrane to the auditory cortex, the system is organized spatially with respect to frequency. Each place on the basilar membrane responds best to a specific frequency high-frequency sounds are localized to the base, and low-frequency sounds, to the apex. The tonotopic organization of the cochlea is preserved at the cochlear nucleus.



AUDIOTORY PATHWAY

AIMS AND OBJECTIVES

1. To Study the Facial nerve course,status of ossicles,position of jugular bulb, cochlear turns and vestibule ,Cochlear nerve by radiology and correlate with intra-operative findings.

2. To Study the efficacy of radiological evaluation (HRCT temporal bone and MRI brain and cochlear nerve.

MATERIALS

- **STUDY PLACE** : Rajiv Gandhi Government General Hospital, Chennai – 600003.
- **COLLABORATING DEPARTMENT:** Upgraded Institute of Otorhinolaryngology
- **STUDY DESIGN :** Prospective and retrospective study
- **STUDY PERIOD : AUGUST 2013 TO NOVEMBER 2014**
- **ETHICAL COMMITTEE CLEARANCE** : obtained

INCLUSION CRITERIA

- Age 1-6 yrs (Prelingual Child)
- Severe to profound SNHL
- Facial nerve course
- Status of Ossicles
- Jugular bulb position
- Inner ear (Cochlea)

EXCLUSION CRITERIA

- Below 1 year
- Absent Cochlear nerve
- Post-lingual patient.

INVESTIGATIONS

- Routine blood investigation
- Pure tone Audiometry
- Impedance Audiometry
- Behavioral observation Audiometry (BOA)
- Otoacoustic Emissions (OAES)
- Brainstcm Evoked response Audiometry (BERA)
- HRCT temporal bone & cochlea
- MRI of brainb including colchlear nerve
- TORCH test
- Echocardiogram

DATA COLLECTION

CLINICAL BENEFIT TO THE COMMUNITY

- To Restore Hearing
- Lesser Morbilidity
- Lesser post operative complications
- Early speech development
- To bring back Normal Social well being of the child

CONFLICT OF INTEREST : NIL

FINANCIAL SUPPORT : NIL

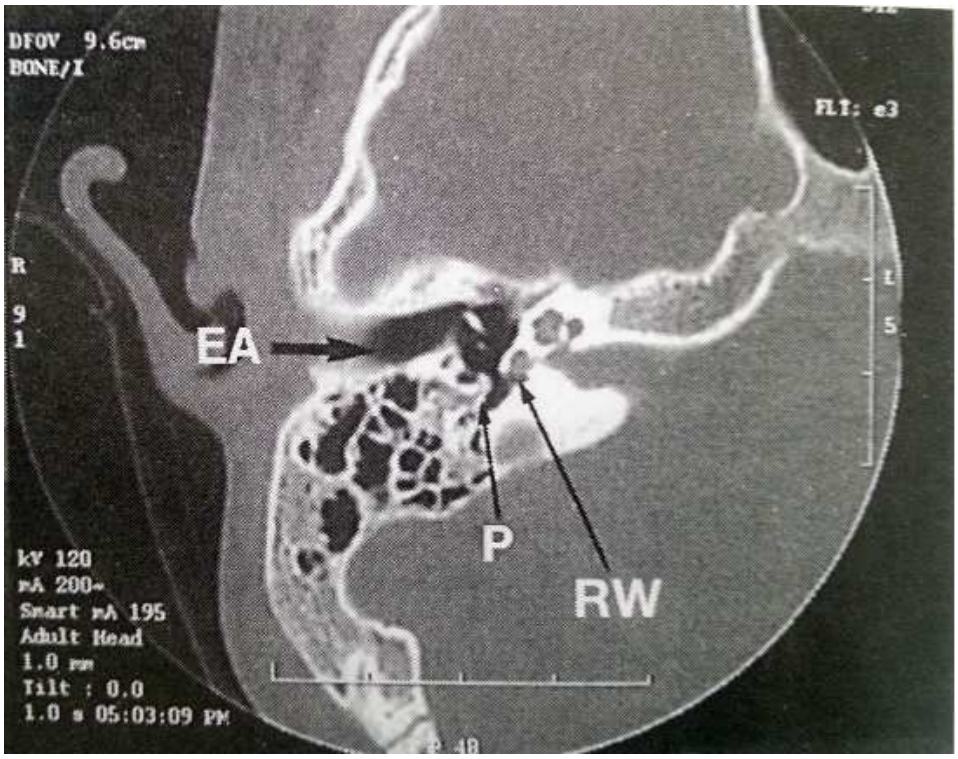
METHODOLOGY

The study was conducted in the tertiary care Rajiv Gandhi Government general hospital and madras medical college in the department of upgraded institute of otorhinolaryngology.

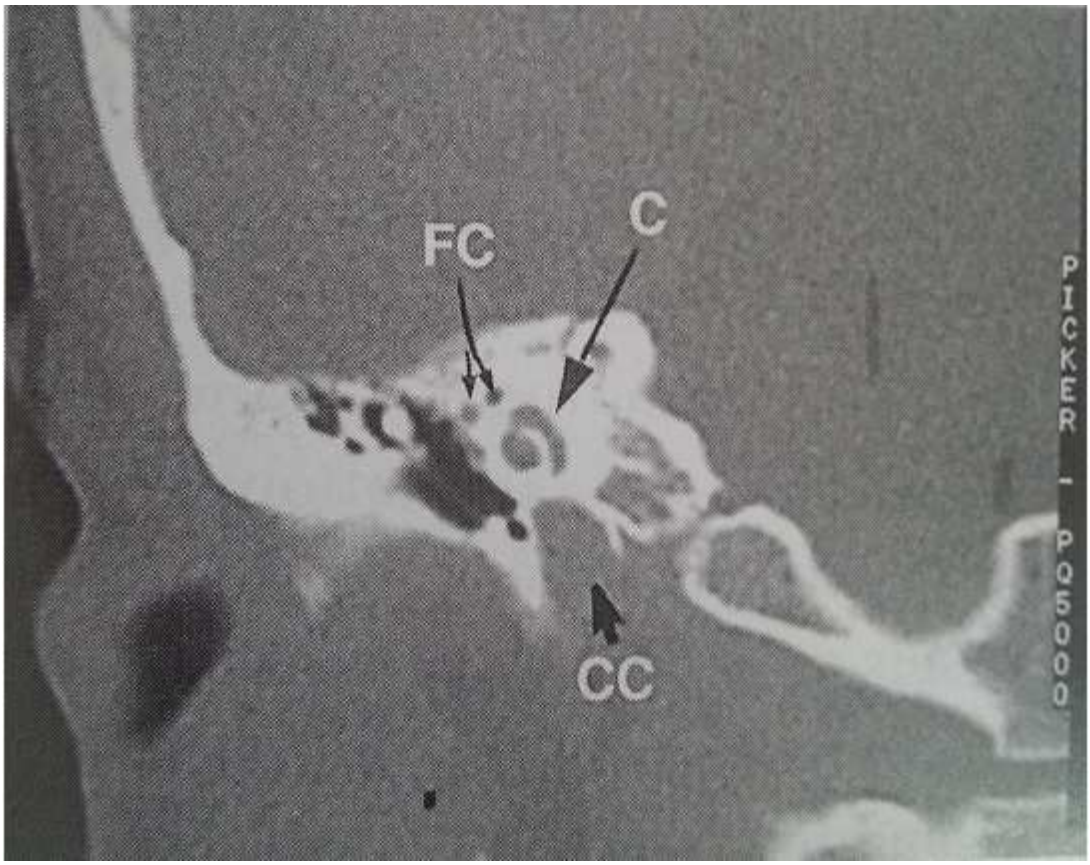
Prelingual children (1-6 years) with severe to profound sensorineural hearing loss coming to upgraded institute of otorhinolaryngology, rajiv gandhi govt general hospital who satisfy the inclusion criteria.

IMAGING PROTOCOL HRCT SCAN

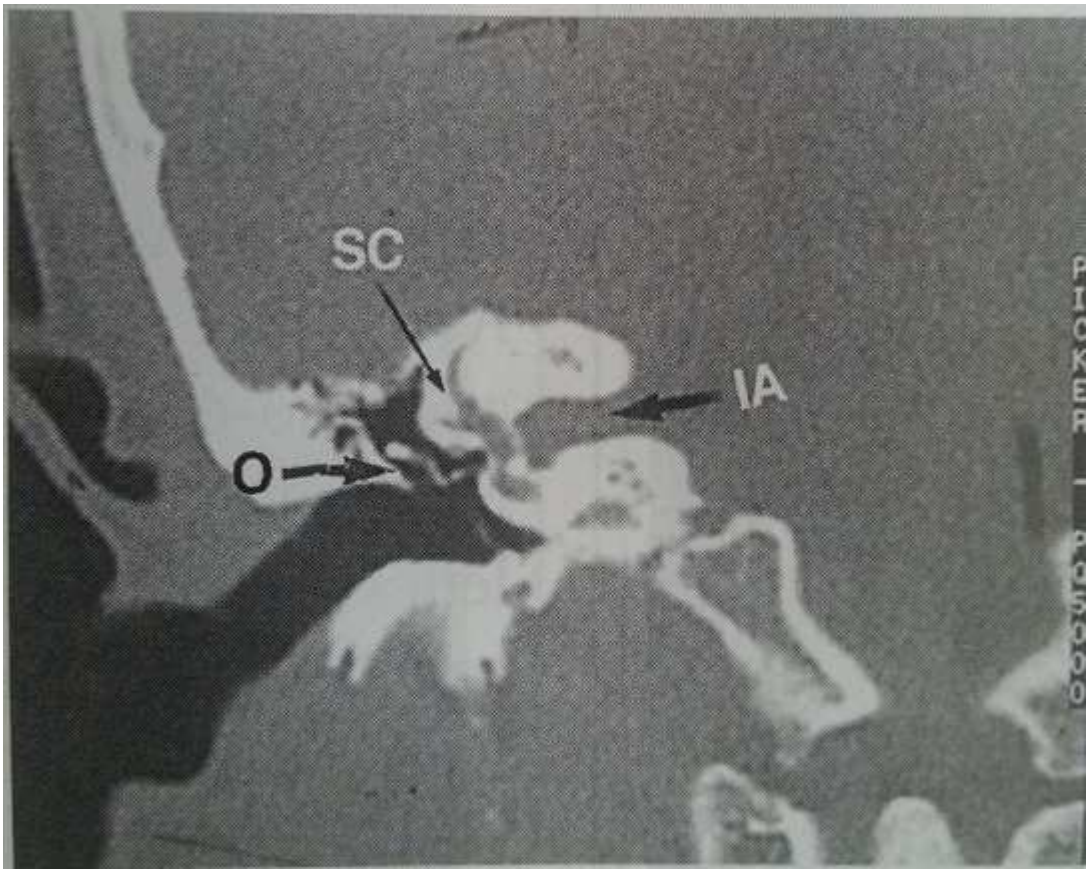
All HRCT investigations were performed in the axial orientation using multislice light speed with slice thickness of 1 mm and ultrahigh algorithm. These are documented in a bone window. Coronal and sagittal reconstruction are performed volume rendered images. All images were evaluated as advantage windows work stations.



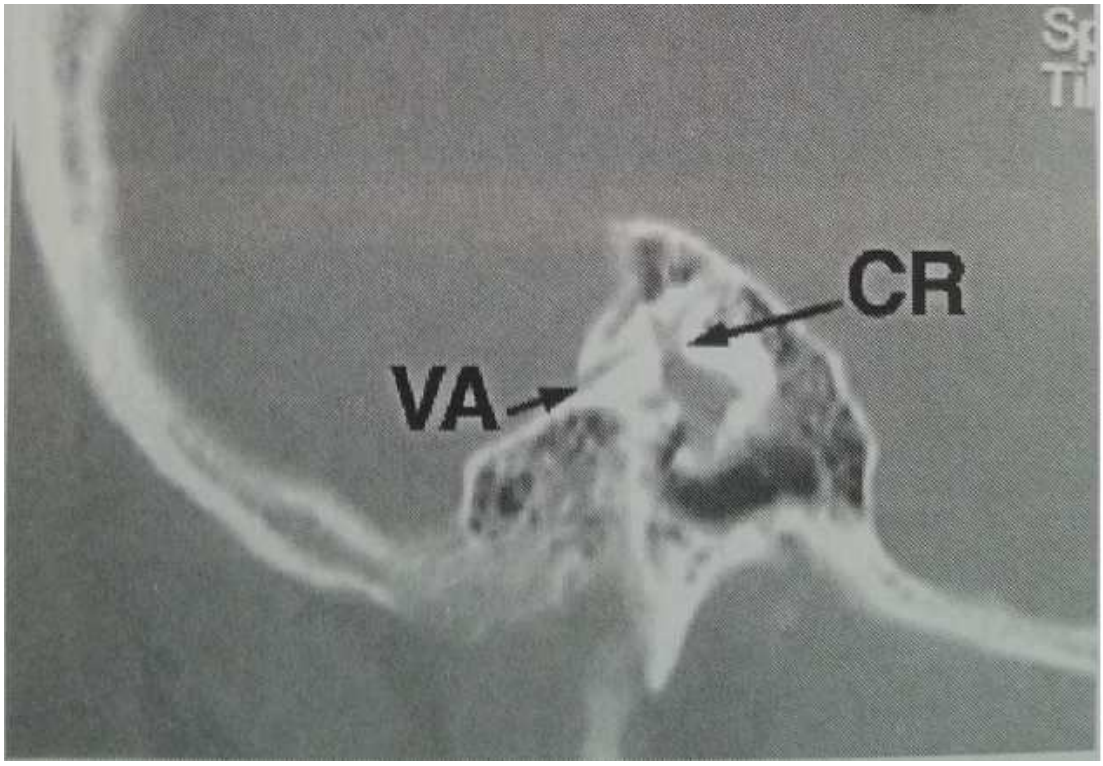
CORONAL SECTION OF NORMAL TEMPORAL BONE



HRCT AXIAL SECTION OF TEMPORAL BONE



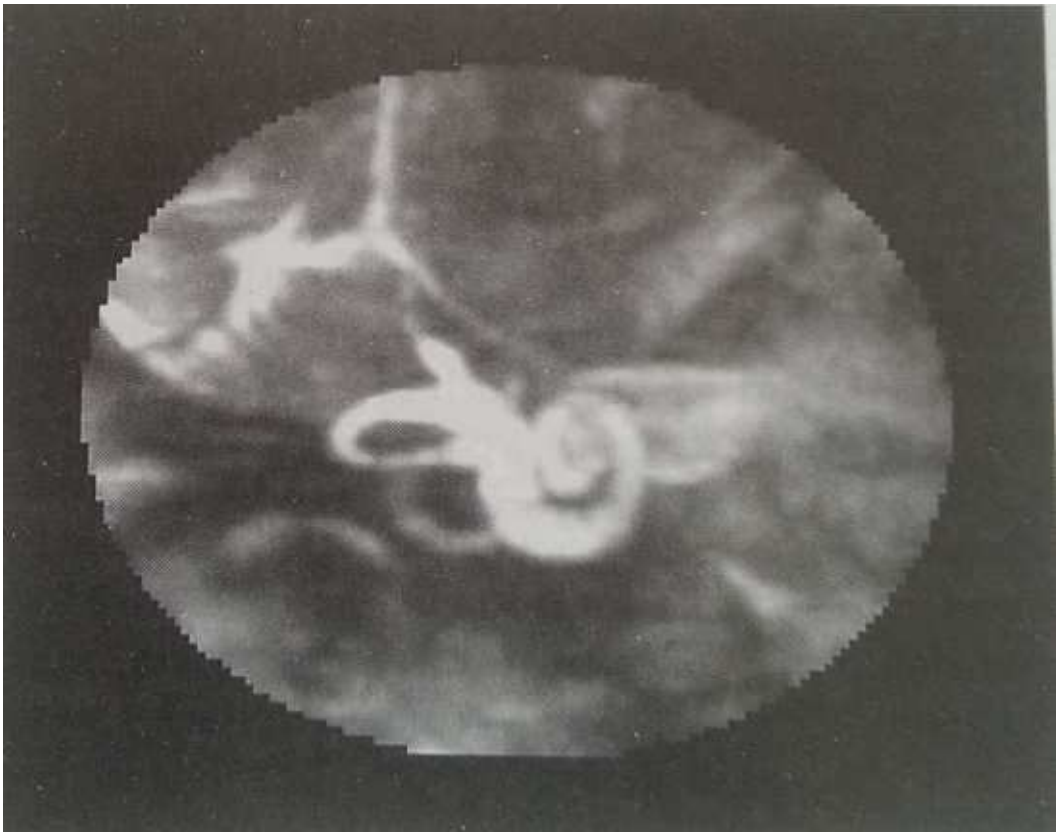
HRCT AXIAL SECTION OF TEMPORAL BONE



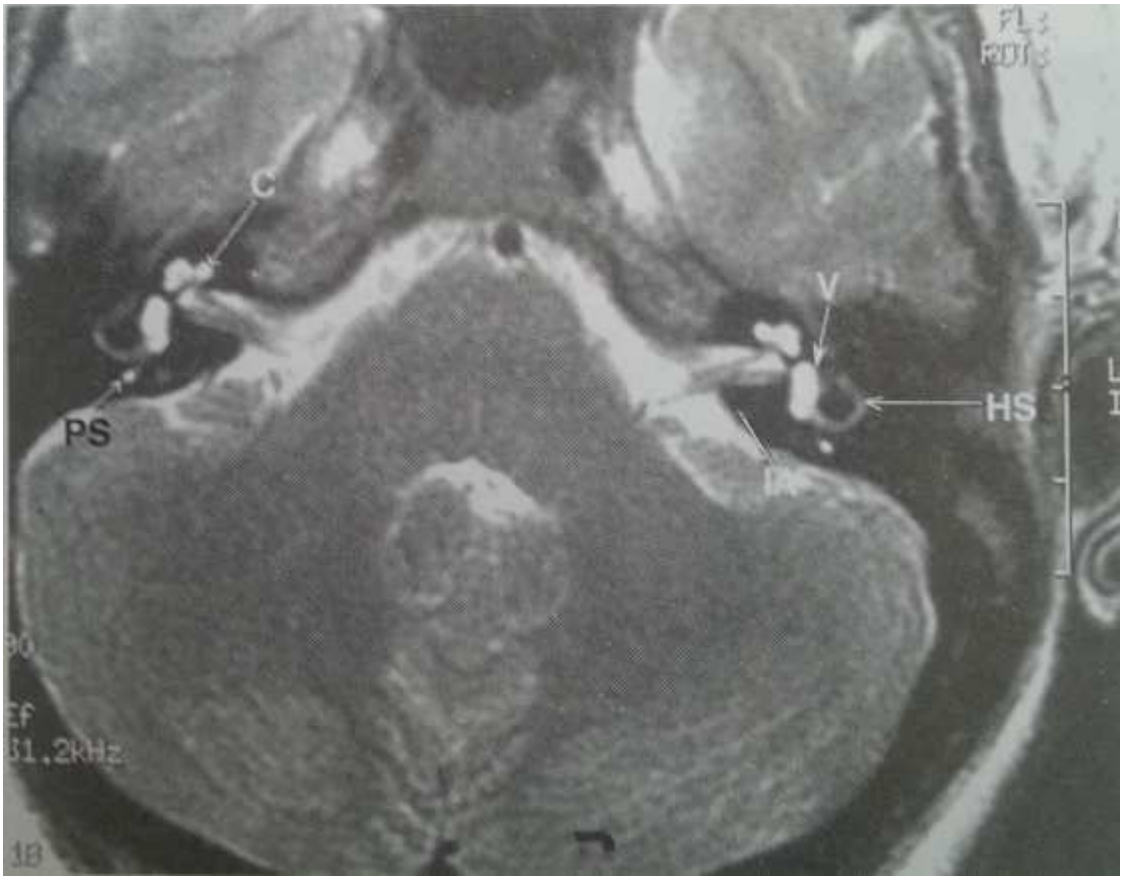
AXIAL SECTION OF NORMAL TEMPORAL BONE

MRI SCAN

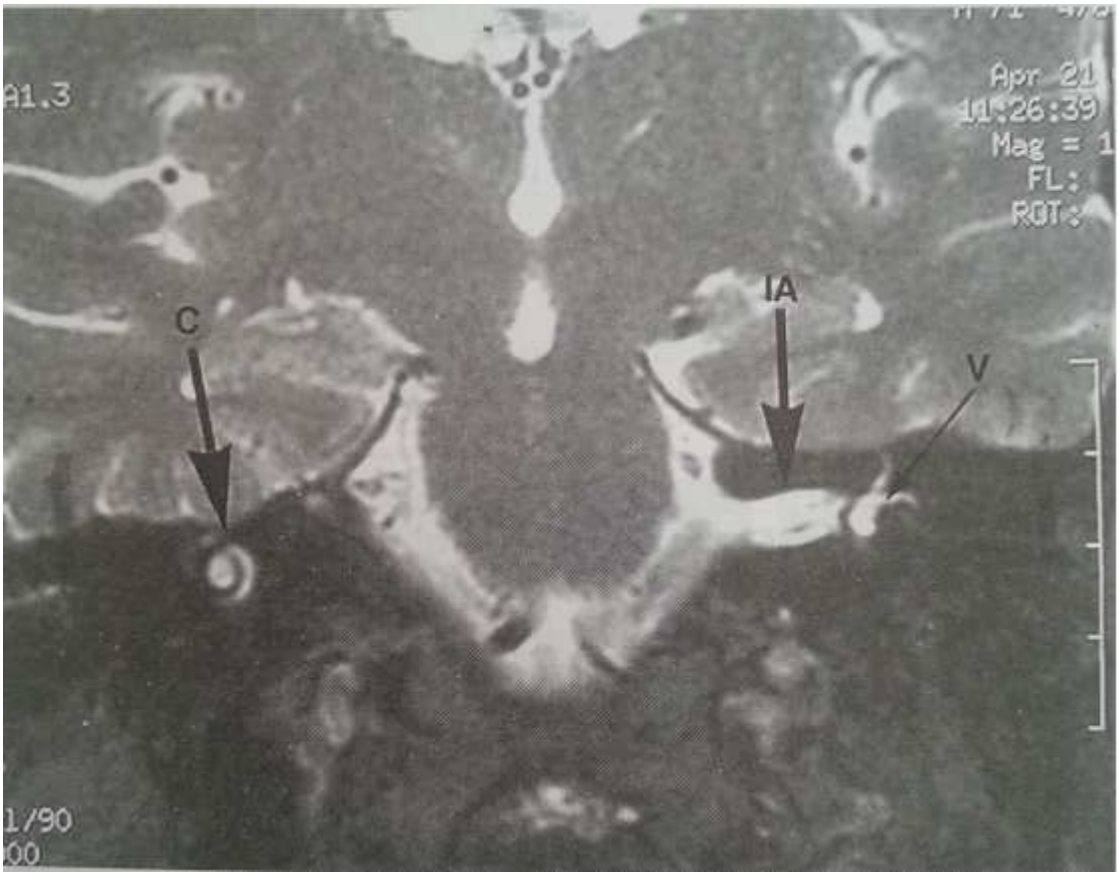
MRI were performed using 3tesla MRI scanner using an 8 channel head coil and the space sequence(heavily T2 weighted). Images are viewed on a seimens work station in multiple planes.



3D RECONSTRUCTION OF COCHLEA



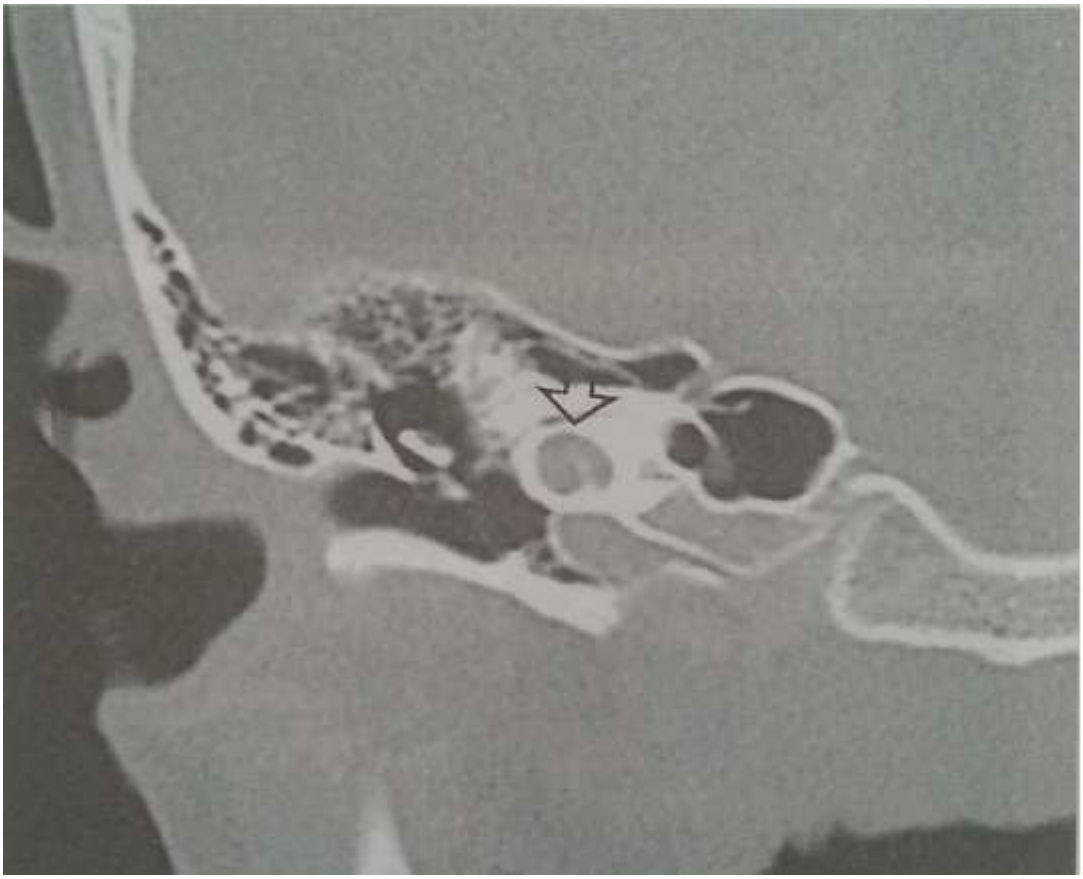
MRI OF TEMPORAL BONE- AXIAL



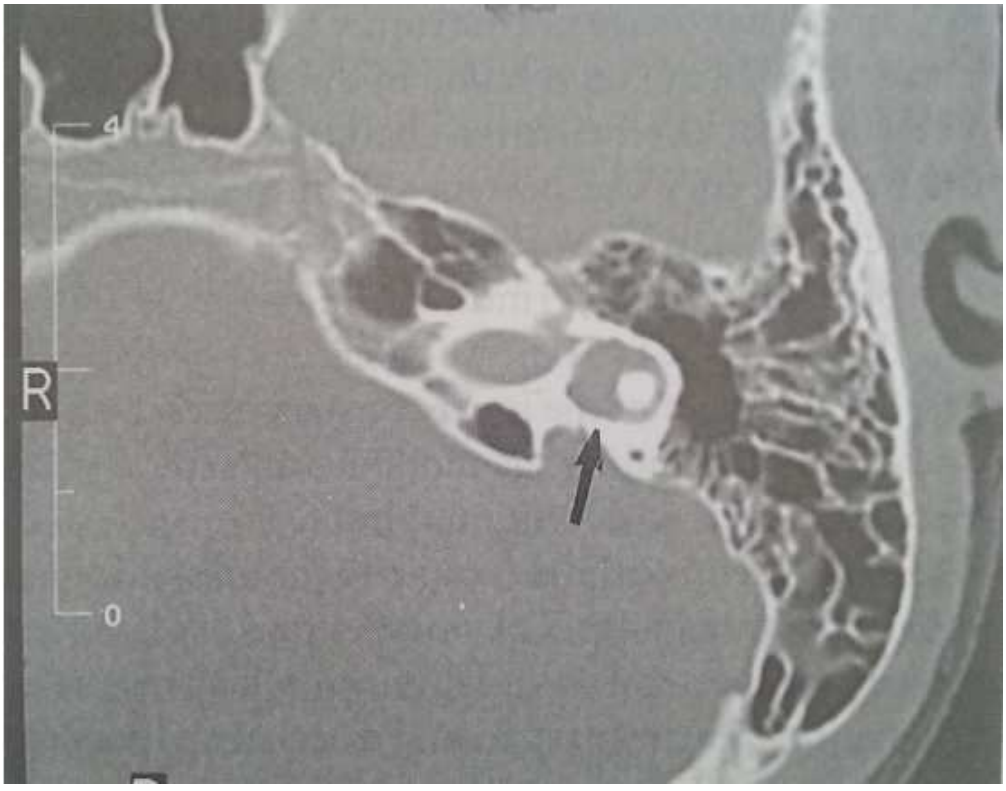
MRI OF TEMPORAL BONE- CORONAL SECTION

COCHLEAR MALFORMATIONS

There is much confusion in the literature regarding the nomenclature of cochlear morphologic anomalies, especially regarding the term “Mondini malformation.” In 1791, Carlo Mondini presented his findings on an anatomic dissection of a young deaf boy. During his dissection on the posterior face of the petrous bone Mondini discovered significant vestibular aqueduct enlargement, and commented that the usual bony lip that “protects the vestibular aqueduct” was missing and was substituted by a membranous plate of dura. In observing the medial opening of the vestibular aqueduct, Mondini commented that it was quite enlarged and was larger than the size of the common crus. With regard to the cochlea, it was described to possess only one-and-a-half turns. He described the cochlea as ending in a cavity corresponding to the last spiral turn and described an incompletely formed interscalar septum.



MONDINI DEFECT



MONDINI DEFECT

The term Mondini dysplasia was used by Schuknecht in an in-depth analysis of the histopathology and clinical features of cochlear anomalies. Schuknecht's treatise described a variety of malformations including one patient with "the normal 21/2 turns but measuring only 23 mm in length (normal: 32 mm)" and another with "Mondini dysplasia limited to the vestibular system," as well as several patients with cochleae possessing one and-a-half turns, and other variant morphologies of both the cochlear duct and vestibular system.

Phelps reserves the term "Mondini deformity" for cochlea whose basal turns are normal and that possess a deficiency of the interscalar septum of the distal one and-a-half coils.

Jackler and colleagues proposed a classification system in 1987 for the congenitally malformed inner ear based on the theory that a variety of deformities result from arrested development at different stages of embryogenesis. Jackler and colleagues formulated their classification system on review of polytomes and CT scans of 63 patients with 98 congenitally malformed ears. Complete labyrinthine aplasia, also called Michel deformity, could

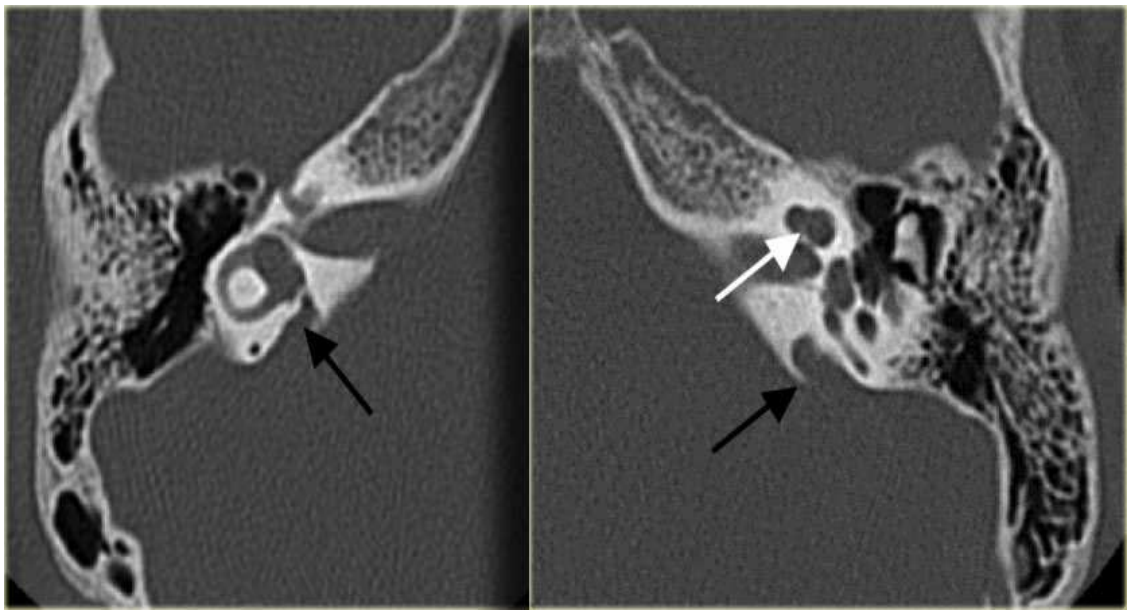
result from arrest prior to formation of the otocyst, resulting in complete absence of inner ear development.

Cochlear aplasia is defined as absent cochlea with an intact but often variably deformed vestibular labyrinth. representing approximately 3% of identified cochlear malformations.

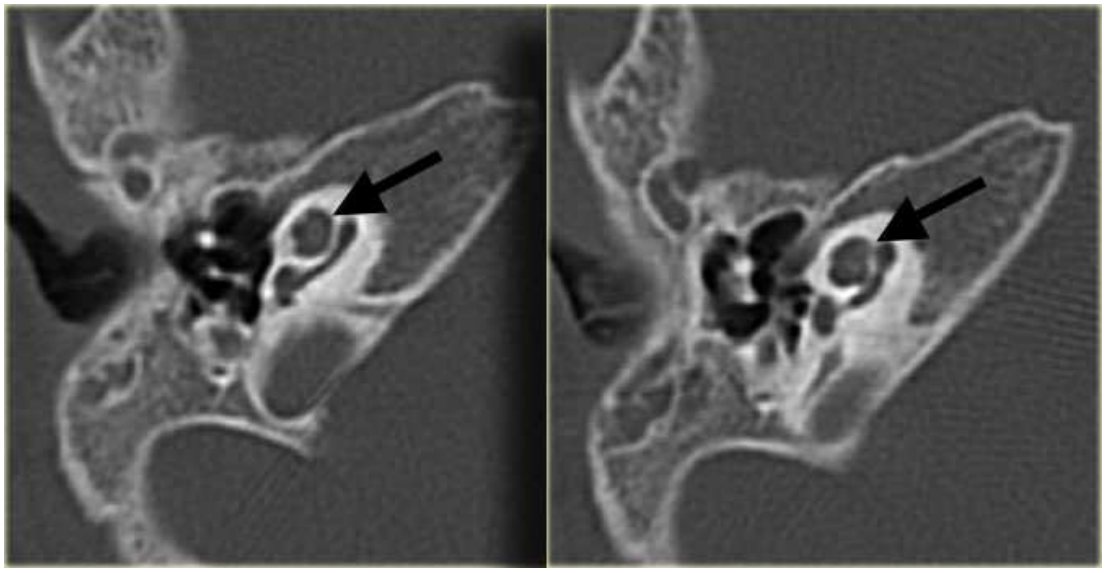
The term cochlear hypoplasia describes a wide range of abnormalities from a rudimentary cochlear diverticulum to an incompletely formed cochlear bud of several millimeters. This group comprised 15% of cases reported by Jackler and colleagues.

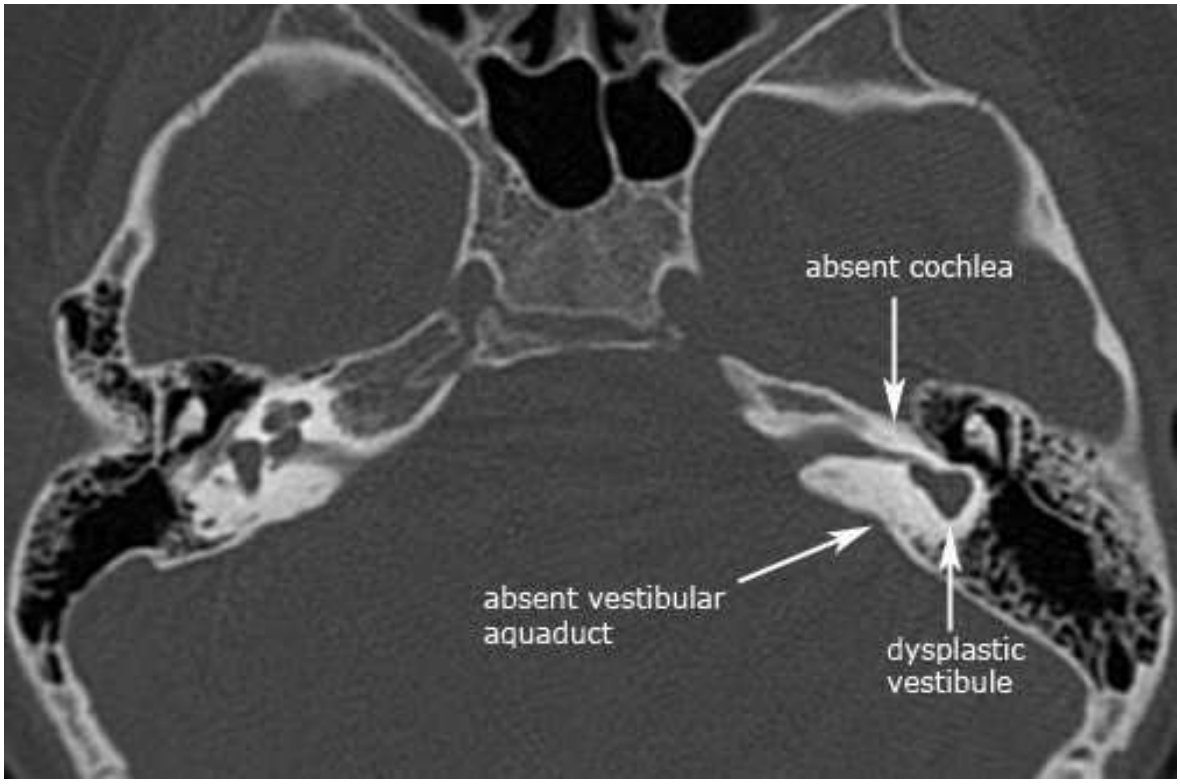
Incomplete partition is a term used by Jackler and colleagues. This cochlear abnormality is the most commonly described, making up 55% of the study described.

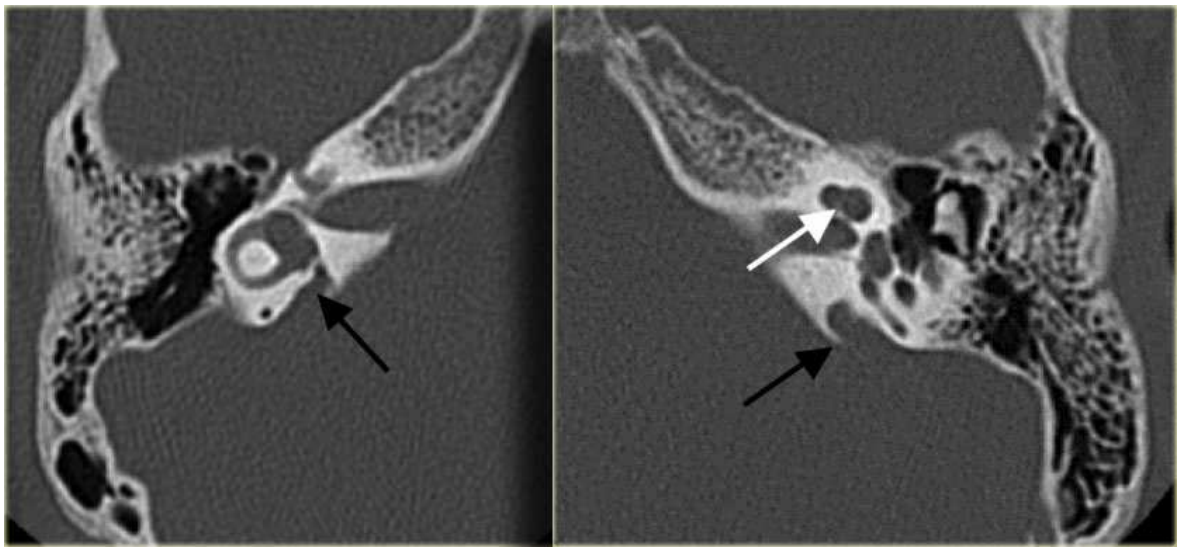
The term common cavity is used to denote confluence of the cochlea and vestibule into a common rudimentary cavity that usually lacks an internal architecture and is often associated with abnormally formed semicircular canals and comprised 26% of the study by Jackler and colleagues.

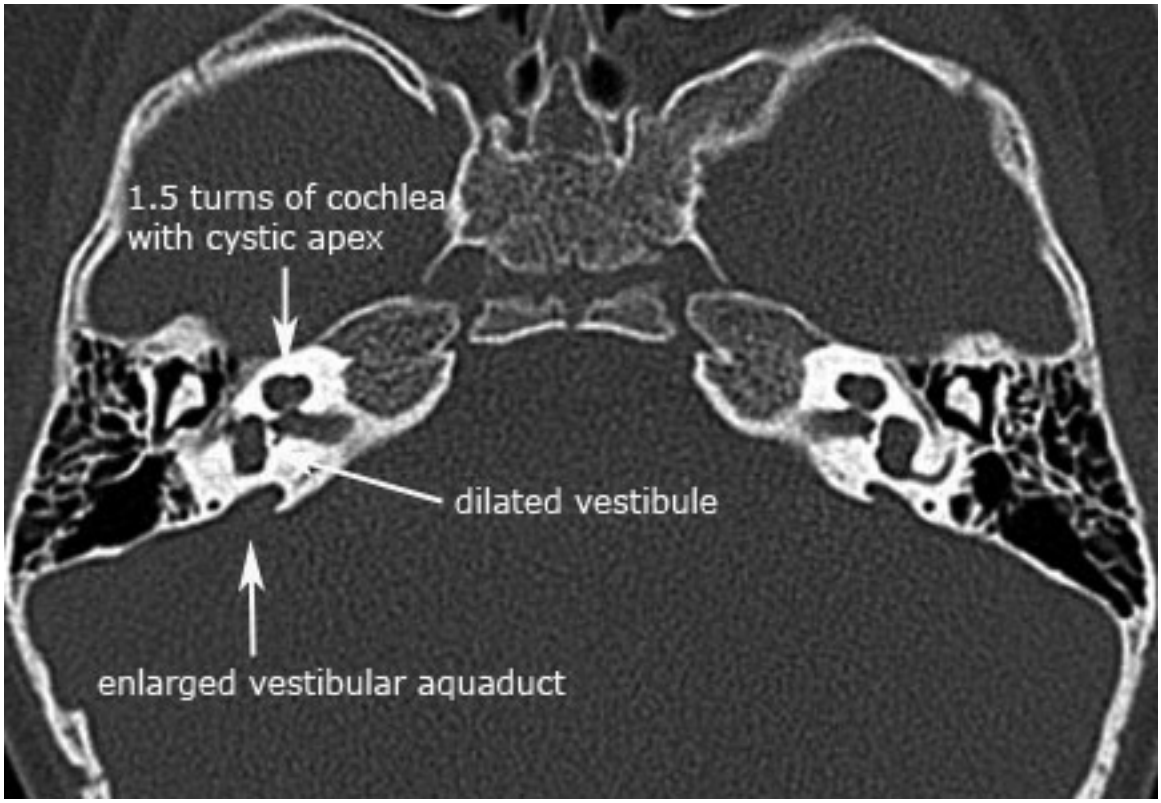


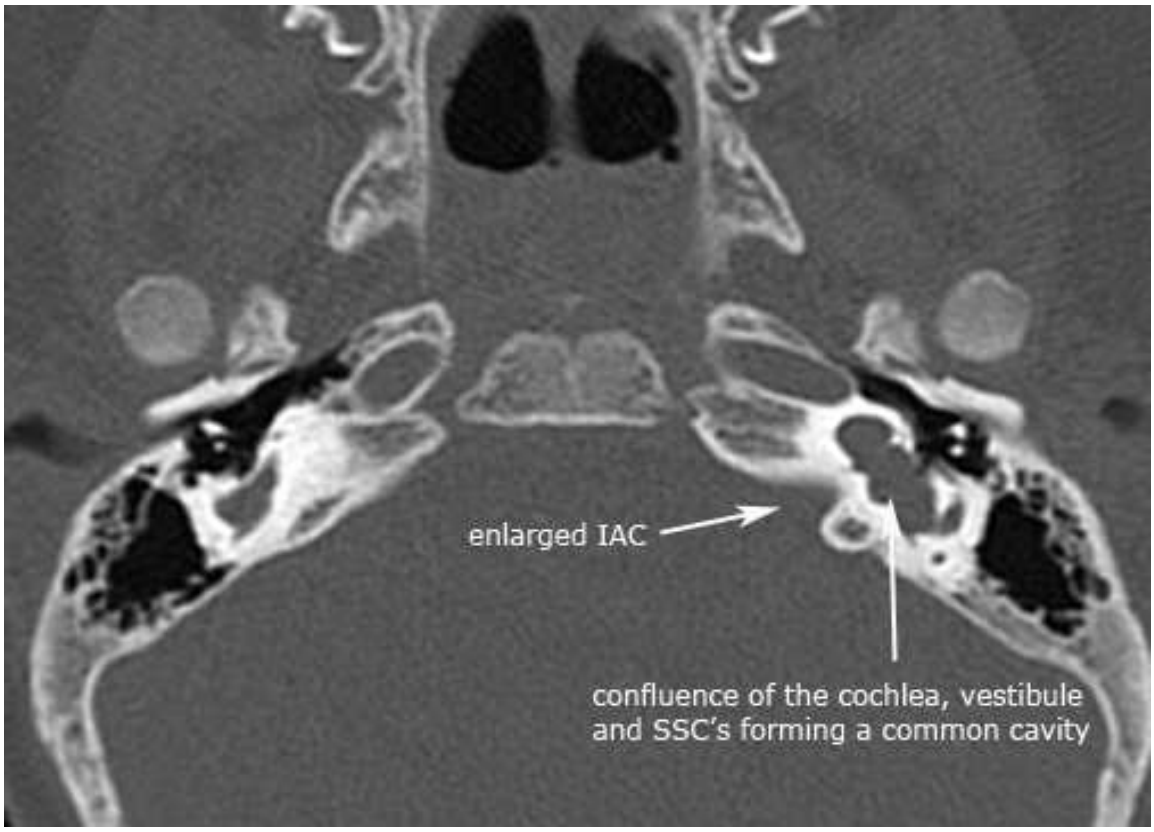
ENLARGED COCHLEOVESTIBULAR AQUEDUCT

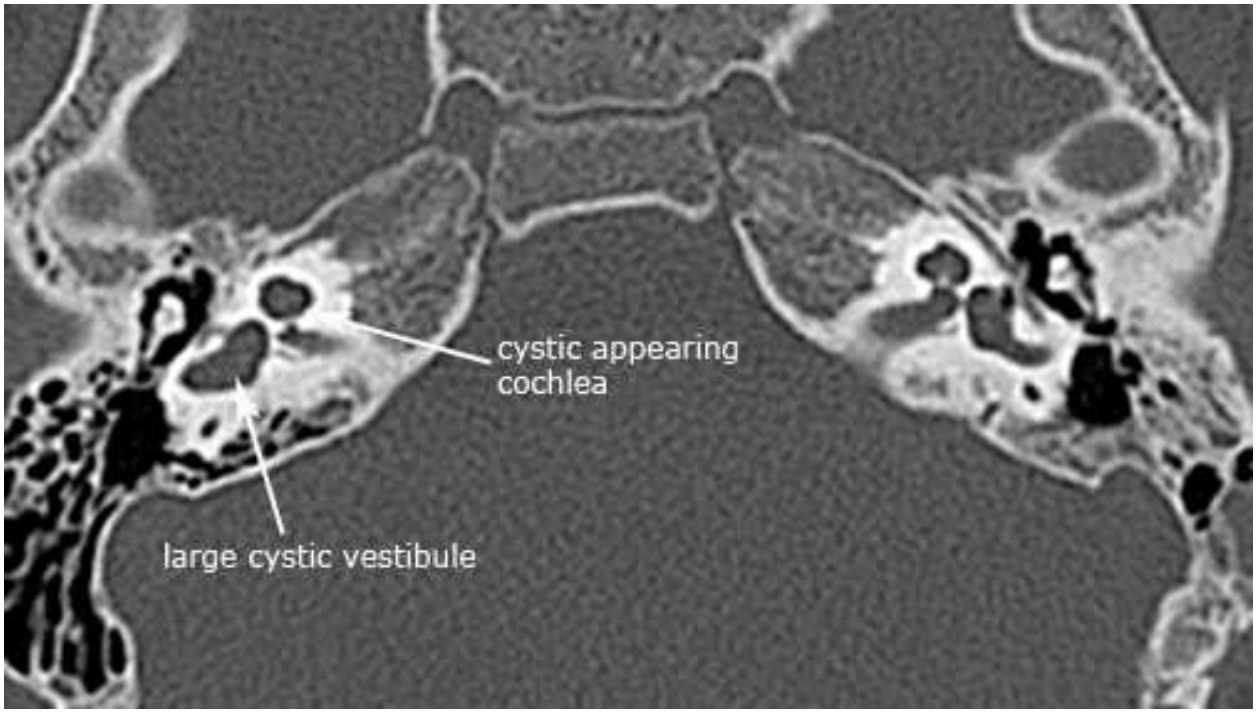


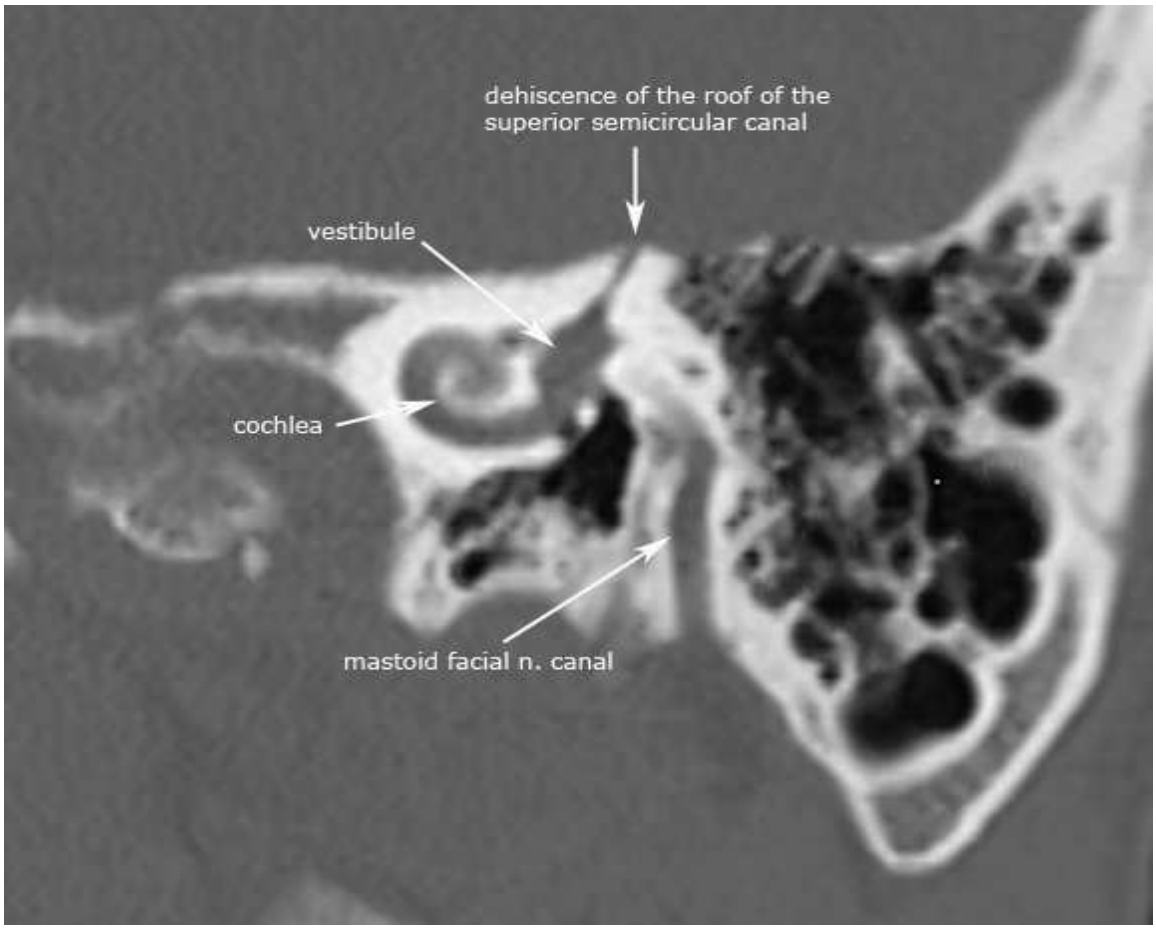

absent cochlea
absent vestibular aquaduct
dysplastic vestibule




1.5 turns of cochlea
with cystic apex
dilated vestibule
enlarged vestibular aquaduct


enlarged IAC
confluence of the cochlea, vestibule
and SSC's forming a common cavity


cystic appearing
cochlea
large cystic vestibule


dehiscence of the roof of the
superior semicircular canal
vestibule
cochlea
mastoid facial n. canal

Jackler's classification of congenital malformations of the inner ear.

Absent or Malformed Cochlea

1. Complete labyrinthine aplasia

2. Cochlear aplasia

3. Cochlear hypoplasia

4. Incomplete partition

5. Common Cavity

NORMAL COCHLEA

1. Vestibule—lateral semicircular canal dysplasia

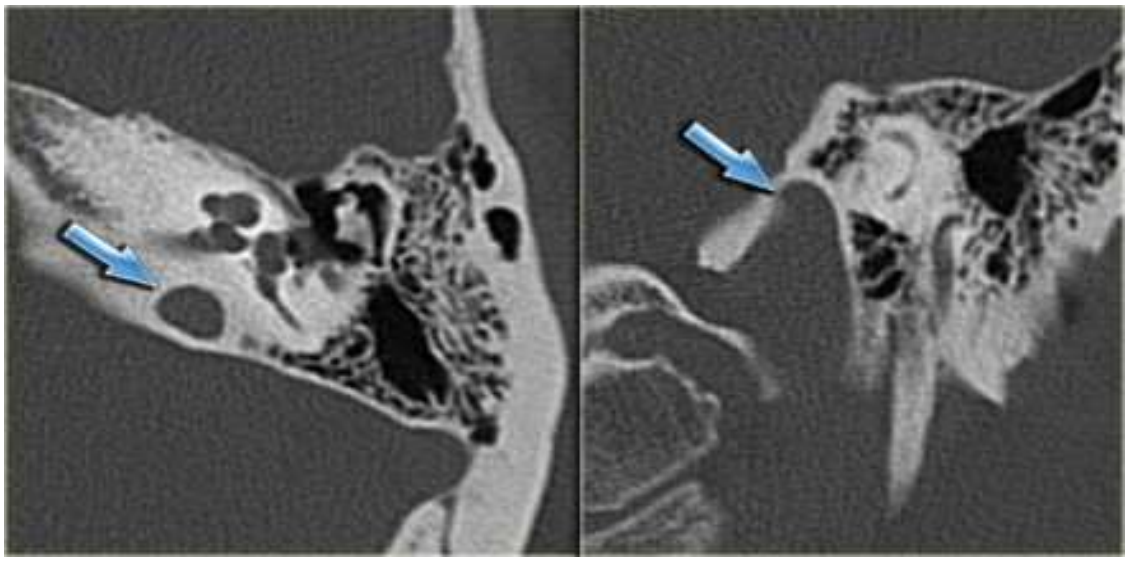
2. Enlarged vestibular aqueduct

A very narrow internal auditory canal of a diameter 2 to 2.5 mm or less on either conventional tomography or CT has been reported in association with a normal inner ear as well as a variety of inner ear malformations. A CT scan demonstrating an internal auditory canal of less than 2 to 2.5 mm is considered by many investigators to be an absolute contraindication to cochlear implantation.

It has been detailed by both CT and MR imaging, and holds the clinical implications that there is an obvious large communication between the CSF-containing internal auditory canal and the cochlea. This situation also presents the concern that a multichannel electrode array may be introduced into the internal canal at the time of implantation.

JUGULAR BULB

Aberrant middle ear vascular anatomy may complicate mastoidectomy and facial recess approach to the cochleostomy. An extreme anterior displacement of the sigmoid sinus against the posterior canal wall reported in 1.6 %. A high riding jugular bulb present in 6 % of population. A high riding jugular bulb may overlie the round window niche or promontory.



HIGH JUGULAR BULB

FACIAL NERVE

Preoperative HRCT is especially useful in identifying the position of the aberrant facial nerve associated with cochlear malformations. The course of the facial nerve is quite unusual and increases risk during cochlear implantation. The careful preoperative review of the position of the facial nerve is warranted for safe and successful implantation. The dehiscence of the intratympanic portion without cochlear malformation may be encountered in the approach to the cochleostomy site.

The mastoid air cell system and tympanic cavity also included in the analysis of preoperative HRCT. The degree of mastoid pneumatisation is useful information in operating in young children.

The fully pneumatised mastoid accounts for 79.5 %, the diploeic being 17.5% & sclerotic being 3 %. Though considered fully developed at birth, the depth of the facial recess as well as its degree of pneumatization may be anticipated.

REVIEW OF LITERATURE

COCHLEAR IMPLANT

HISTORY

Auditory nerve stimulation is required for cochlear implantation. It requires surgical expertise in facial recess approach and considerable post operative speech therapy. Electrical stimulation of the auditory system was first done by an Italian physicist, Alessandro Volta in 1790. By placing the ends of metal rods in his ears connected to an electrical supply, he discovered that the initial “boom in the head” was followed by a electronic sound similar to “a thick boiling soup”—what we know now to be electronic static.

In the early 19th century, the Frenchman Duchenne used current to stimulate hearing. He observed that it was described “as a sound similar to an insect trapped between a glass pane and a curtain.”

Wever & Bray, (1930) discovered that an electrical response recorded in the auditory nerve of a cat was similar to the amplitude and frequency to the sound that stimulated it. Gersuni & Volokhov,

(1936) are credited for observing the effects of an alternating electrical stimulus on hearing.

Stevens & Jones, (1939), observed that various mechanisms were involved in the perception of sound. Direct stimulation of the auditory nerve was performed by Lundberg in 1950 on a human and resulted in the patient hearing noise.

Andre Djourno and Charles Eyries directly stimulated exposed acoustic nerves and found response in humans.

In 1961, William House developed a device to stimulate auditory function. Together with Jack Urban, an engineer, he developed a implant device with a single electrode.

William F House- Father of Neurotology and first person to perform cochlear implantation

Doyle et al., (1964), designed a four-electrode implant.

Simons, (1966) went on to perform a more extensive study by placement of electrodes throughout the vestibule, promontory areas

and modiolar section of the auditory nerve. This allows for stimulation of auditory fibers representing different frequencies.

House, (1976) and Michelson, (1971) developed a scala tympani insertion of electrode and refined the procedure. The first commercially available cochlear implant in the US was the house 3M.

Professor Graeme Clark and colleagues developed a multi-channel cochlea implant, which enhanced the speech recognition in adult patients. Rod Saunders was the first person to receive the multichannel cochlear implant in 1978.

EVALUATION OF COCHLEAR IMPLANT IN PRELINGUAL CHILDREN

Medical History	• Prenatal exposures (TORCH infections, teratogens) • Perinatal concerns (prematurity, low birth weight, neonatal intensive care unit low Apgar score, hyperbilirubinemia, sepsis, intubation) • Postnatal concerns (ototoxins, meningitis, mumps) • Family history • Physical examination • Syndromes • Otitis media • Pneumococcal vaccination
Imaging	• High-resolution computed tomography of temporal bones • Magnetic resonance imaging of the internal auditory canal

Audiologic	Pure tone audiometry Speech discrimination Hearing aid evaluation Speech perception assessment
Speech and Language	Assess language development Screen for articulation disorders
Physiologic	Otoacoustic emissions Auditory brainstem response test Electrically evoked auditory brainstem response test
Cognitive and development	Assess for cognitive and developmental delays
Patient and family counseling	Establish patient and family expectation Assess family commitment to aural rehabilitation protocol Selection of cochlear implant device Informed consent

PEDIATRIC SENSORINEURAL HEARING LOSS

Sensorinueral hearing loss in the paediatric age group can be due to unknown cause, acquired cause and hereditary cause. Unknown cause accounts for

15% to 44% of pediatric patients with sensorineural hearing loss. Approximately 15% to 40% of sensorineural hearing loss in pediatric patients is of acquired cause, due to pre and perinatal exposure to teratogens and infections.

Sensorineural hearing loss has a hereditary cause in most pediatric patients, accounting for approximately 40% to 50% in most reports. It is due to syndromic and non syndromic. Mutations within the connexin 26 genes, namely the GJB2 and GJB 6 genes, are responsible in most cases. Patients with deafness associated with mutations in the connexin 26 genes have been found to be excellent candidates for cochlear implantation because they perform equal to or better than other cochlear implant patients in reading comprehension, nonverbal cognition, speech performance, language perception, speech perception, and speech intelligibility.

Electrophysiologic testing is of particular importance in evaluating younger pediatric patients (24 months of age) and patients with development delay. Electrophysiologic testing serves as an objective measure of audiologic function.

The presence of stimulability and auditory brainstem response has been correlated with postoperative stimulability after cochlear implantation. Electrically evoked auditory brainstem response testing assists in the selection of the ear for implantation in patients without any residual hearing.

FUNCTION AND COMPONENTS OF COCHLEAR IMPLANT

Cochlear implant is an electrical devise which stimulates auditory nerve and restores useful hearing in patients with severe to profound hearing loss. It bypasses the outer, middle and inner ear and provide information through direct Electrical stimulation of the spiral ganglion. It is the only working prosthesis for functional replacement of a sensory organ.

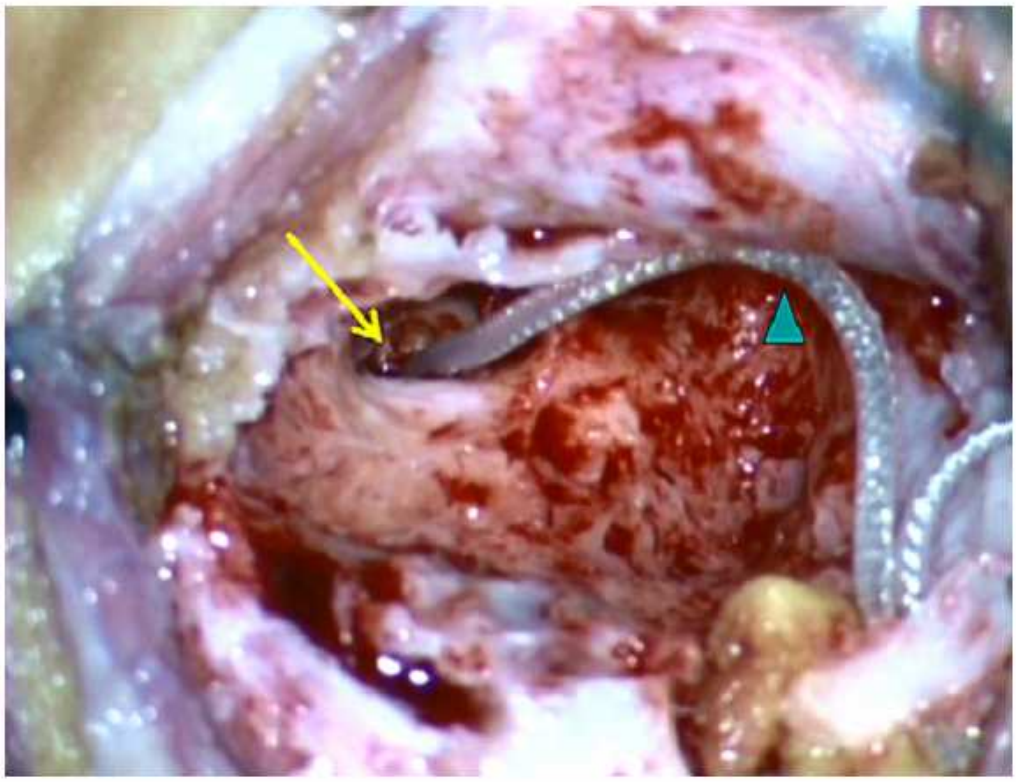
It has external and internal components, the external components consist of a behind the ear (BTE)speech processor and radio frequency coil with magnet. Internal components are the receiver/stimulator, the active stimulation electrode and ground

electrode. The cochlear implant has to convert the initial sound signa into electrical pulses.

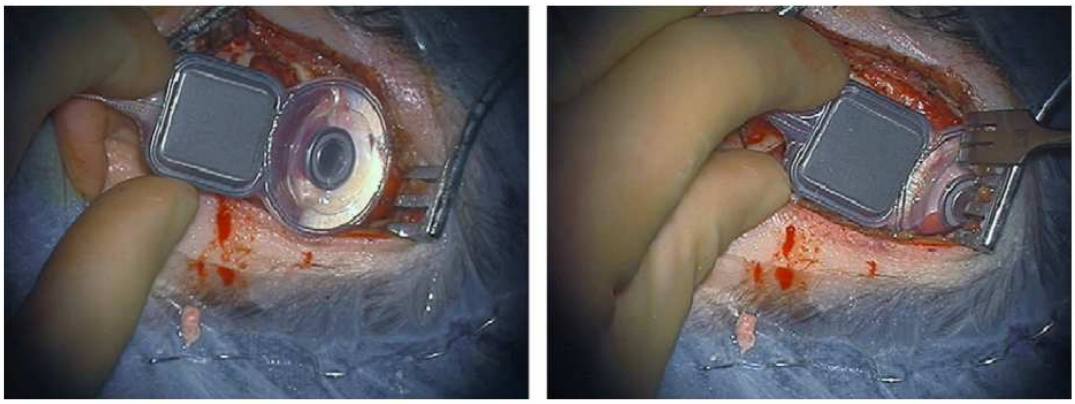
SURGICAL APPROACHES

MASTOIDECTOMY WITH POSTERIOR TYMPANOTOMY APPROACH

In 1961, Dr House introduced the mastoidectomy with posterior tympanotomy approach (MPTA) for cochlear implantation. As the name implies, a mastoidectomy is performed followed by a posterior tympanotomy, which opens the facial recess exposing the round window. Several techniques have been developed and explored to try to minimize the extent of surgery needed to place the implant and the risk to the facial nerve and chorda tympani.



FACIAL RECESS APPROACH



RECIEVER

SUPRAMEATAL ROUTE

Kronenberg and colleagues developed a technique that avoids a mastoidectomy altogether and introduces the electrode into the middle ear via a suprameatal

route. This suprameatal approach is based on a retroauricular tympanotomy approach to the middle ear in which the facial nerve is protected by the body of the incus.

Drawbacks to the suprameatal approach are

The electrode is stretched during insertion into the cochleostomy.

Low-lying dura is a relative contraindication.

A round window insertion and inferior cochleostomy is difficult.

The revision surgery rate is much higher with this technique

ENDAURAL APPROACH

This endaural approach, also known as the Veria operation, requires a special perforator for drilling a direct tunnel and a safety electrode forceps for inserting the electrode.

MINIMAL ACCESS INCISION TECHNIQUES

A percutaneous cochlear implant technique that involves a single, image-guided drill passed from the mastoid cortex through the facial recess to access the cochlea has been developed. Access to correct cochleostomy or round window insertion may also be limited and the 3-D approach to scala tympani insertion is limited.

SECURING THE COCHLEAR IMPLANT

Balkany and colleagues described the temporalis pocket technique obviating drilling a well or fixation of any type. The theory behind this technique is based on the anatomic limitations of the temporalis pocket, which is bounded “anteriorly by dense condensations of pericranium anteriorly at the temporal-parietal suture, posteroinferiorly at the lamboid suture, and anteroinferiorly by the bony ridge of the squamous suture.” It is widely used technique for securing the implant.

Other techniques include

- Drilling two 4-mm titanium screws on either side of the well and connecting them with a 3-0 nylon suture
- Applying polypropylene mesh over the R/S and securing the mesh with titanium screws.
- Cementing the R/S with ionomeric bone cement.
- Securing the proximal portion of the electrode by placing it in a drilled-out groove connecting the well and mastoid, thus eliminating the need for fixation of any type.
- Sewing the periosteum together over the implant.

SURGICAL STEPS

- Post auricular incision and preparations of the musculo-periosteal flap to fix the implant
- Cortical mastoidectomy.
- Facial recess approach
- Antero-inferior Cochleostomy into scala tympani through round window niche/ round window.
- Insertion of Cochlear implant electrode.
- Sealing of cochleostomy with connective tissue.

- Drilling of bony well for receiver/stimulator.
- Fixation of receiver/stimulator and electrode wire.
- Intra operativbe tests to assure correct functions and placement of implant.

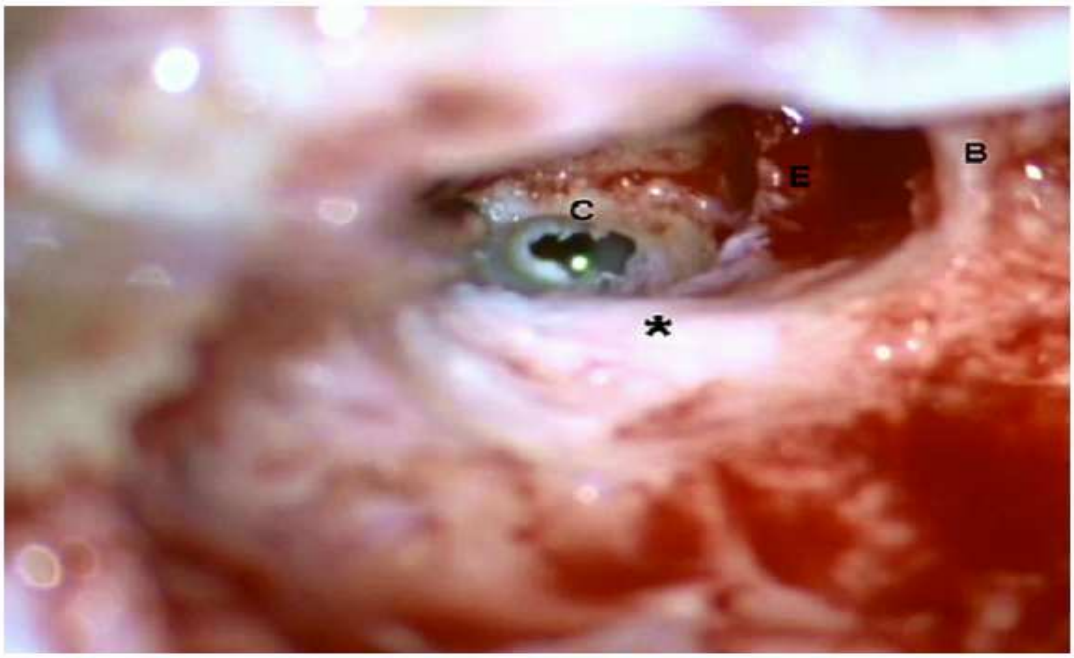
INSERTION TECHNIQUE OF ELECTRODE

COCHLEOSTOMY TECHNIQUE

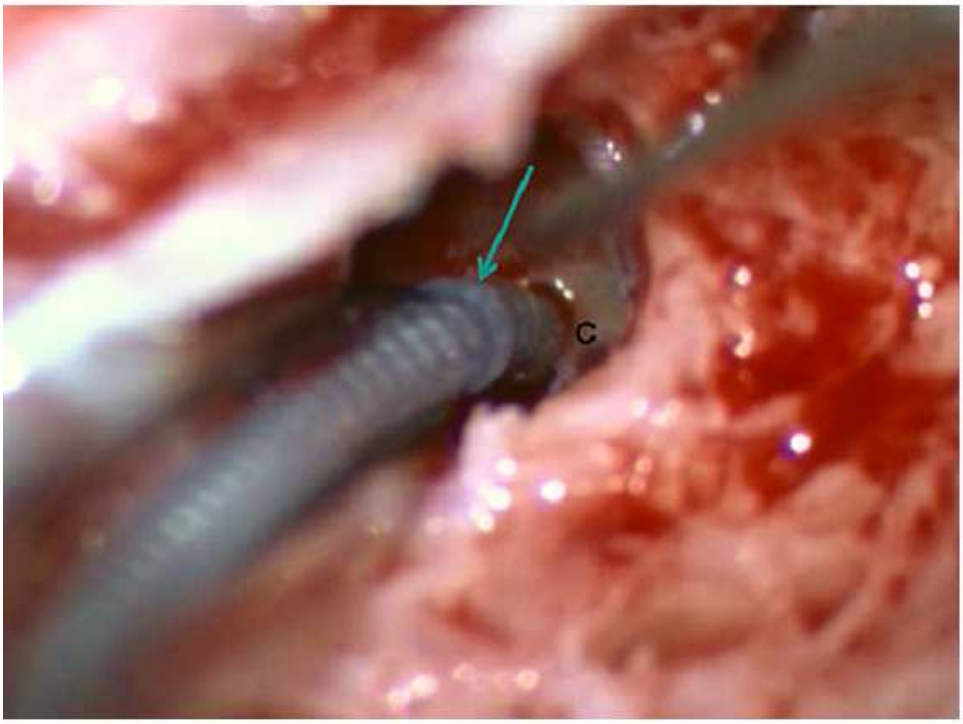
- The traditional way to drill the cochleostomy is through the promontory anterior and inferior to the round window membrane using a 1-mm to 1.5-mm diamond burr .
- The round window membrane is usually 1-mm to 1.5-mm inferior to the stapes tendon.
- If necessary, the round window niche is removed to identify the round window.
- Meticulous drilling with a 1-mm diamond burr is then used and continued until the “blue” lining of the endosteum is visible, taking care to avoid inadvertent penetration of the endosteum because this may expose the inner ear to significant acoustic trauma, up to 130 dB.
- The endosteum is at the same level and is continuous with the round window membrane.
- The size of the cochleostomy is determined by the size of the electrode array, which ranges from 1.0 mm to 1.4 mm.
- Once the endosteum is exposed, great care is taken to prevent bone dust or blood from entering into the cochleostomy. Some

centers encourage the use of hyaluronic acid or dilute surgical-grade glycerin at this point to prevent entrance of blood and bone dust.

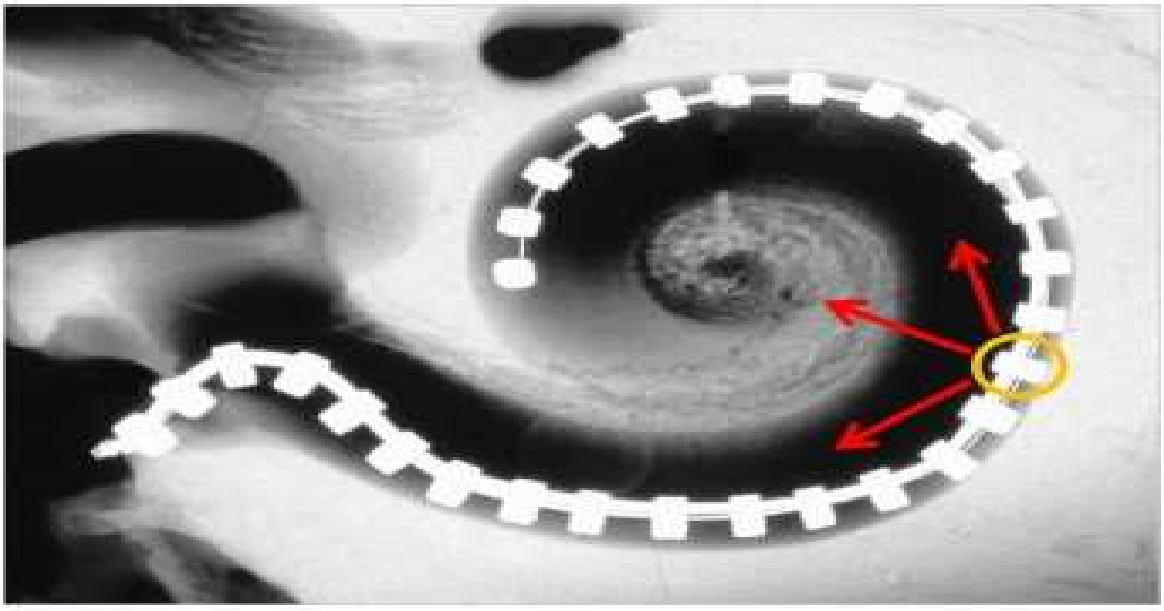
- These substances have a buoyant density greater than bone dust and blood, thus preventing ingress to the scala tympani.
- At this point, a straight pick is used to open the endosteum and the electrode is inserted.
- Suction is prohibited at this stage to avoid loss of perilymphatic fluid. Systemic and/or topical intratympanic steroids may be used in hearing preservation cases.



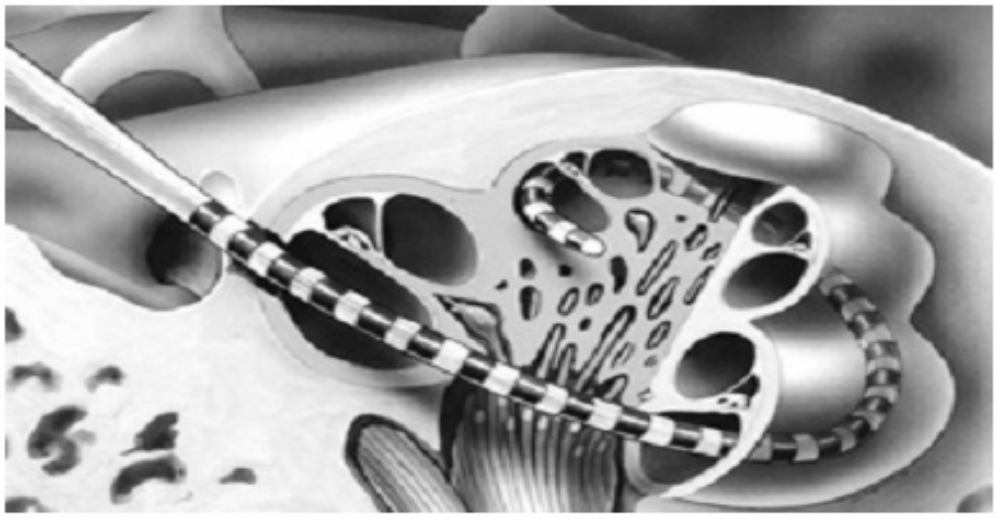
COCHLEASTOMY



INSERTION OF ELECTRODE



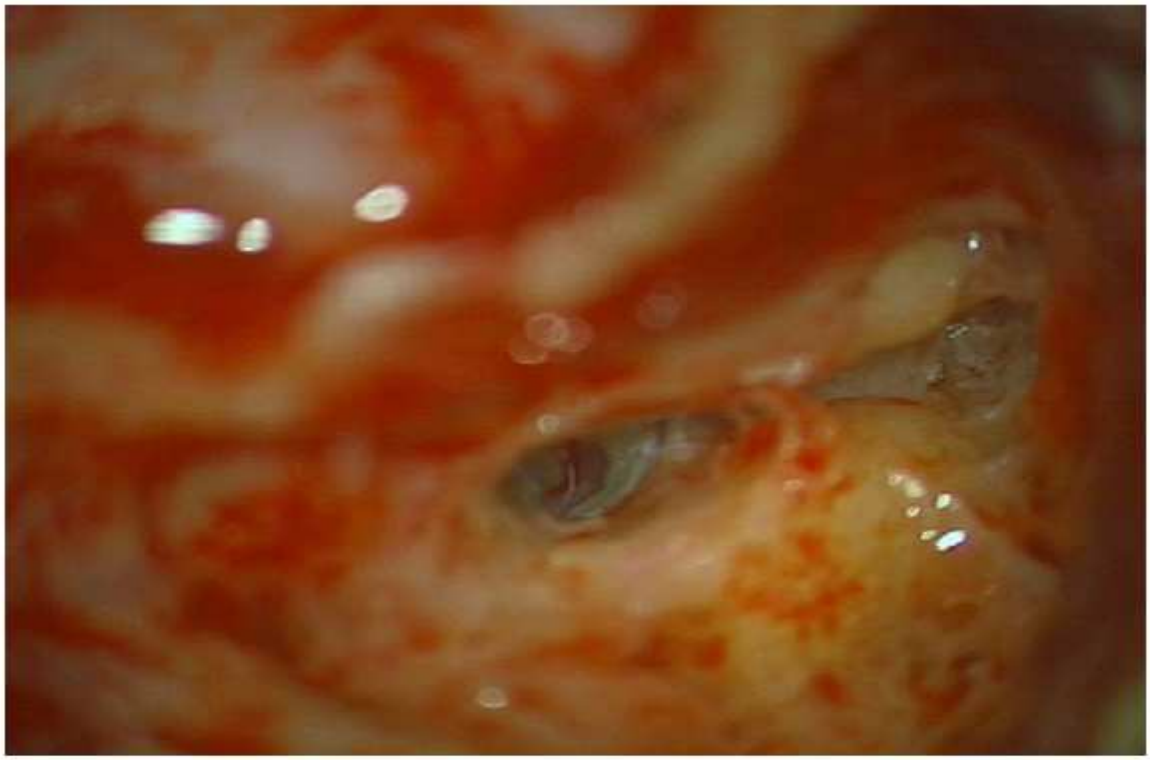
ELECTRODE ARRAY IN COCHLEA



ELECTRODE DISTRUBUTION

ROUND WINDOW TECHNIQUE

- To avoid insertion into the wall of the scala tympani, the electrode is inserted into the round window at an oblique/anterior angle to the surface. The electrode itself seals the insertion incision, and further sealing is accomplished with muscle and /or periosteum.
- Good visualization of the round window may be achieved in most cases by removing the bony round window niche with a 1-mm diamond as well as performing an adequate facial recess with drilling away of the bone anterior to the descending facial nerve over the stapedius muscle.



ROUND WINDOW INSERTION

The round window approach preserves the residual low frequency hearing and electro acoustic stimulation in children. In addition to avoiding the potential trauma that the inner ear experiences from the 130 dB produced from drilling the traditional cochleostomy, the round window approach may reduce postoperative vertigo.

INTRAOPERATIVE MONITORING OF COCHLEAR NERVE

Intraoperative monitoring and the integrity of the cochlear nerve measured by using telemetry. The following responses are monitored

- Impedence telemetry
- Integrity testing
- Electrical stapedial reflex response
- Electrical auditory brainstem response
- Neural response telemetry(ECAP)

Normal intraoperative findings provided immediate reassurance to the implant team and parents of young children that the implant was fully functioning and that electrical stimulation was activating the auditory pathways.

COMPLICATIONS OF COCHLEAR IMPLANT SURGERY

The risks of cochlear implantation mimic those of mastoidectomy. These include

- postoperative infection
- facial paralysis
- cerebrospinal fluid leak
- meningitis
- seroma formation
- perilymph gusher
- giddiness
- flap necrosis
- device failure

STATISTICS

DESCRIPTIVES

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	30	2	6	4.60	1.303
Valid N (listwise)	30				

FREQUENCIES

FREQUENCY TABLE

Group

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cochleostamy	18	60.0	60.0	60.0
	Round Window	12	40.0	40.0	100.0
	Total	30	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	3	10.0	10.0	10.0
	3	4	13.3	13.3	23.3
	4	3	10.0	10.0	33.3
	5	12	40.0	40.0	73.3
	6	8	26.7	26.7	100.0
	Total	30	100.0	100.0	

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	15	50.0	50.0	50.0
	Female	15	50.0	50.0	100.0
	Total	30	100.0	100.0	

Facial Nerve - Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Ossicles - Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Cochlear Turn's - Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnorma	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Cochlear Nerve - Preop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Facial Nerve - INTRAop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnormal	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Ossicles - INTRAop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

Jugular Bulb - INTRAop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnormal	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Cochlear Turn's - Intraop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	29	96.7	96.7	96.7
	Abnormal	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Cochlear Nerve - Intraop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal	30	100.0	100.0	100.0

CROSSTABS

Warnings

No measures of association are computed for the crosstabulation of Facial Nerve - Preop * Facial Nerve - Postop. At least one variable in each 2-way table upon which measures of association are computed is a constant.

Facial Nerve - Preop * Facial Nerve - intraop Crosstabulation

			Facial Nerve - intraop		
			Normal	Abnormal	Total
Facial Nerve - Preop	Normal	Count	29	1	30
		% of Total	96.7%	3.3%	100.0%
Total		Count	29	1	30
		% of Total	96.7%	3.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.[a]		
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	30		

a. No statistics are computed because Facial Nerve - Preop is a constant.

b. Computed only for a PxP table, where P must be greater than 1.

CROSSTABS

Warnings

No measures of association are computed for the crosstabulation of Os Preop * Ossicles - Postop. At least one variable in each 2-way table upc measures of association are computed is a constant.

Ossicles - Preop * Ossicles - intraop Crosstabulation

			Ossicles - intraop	
			Normal	Total
Ossicles - Preop	Normal	Count	30	30
		% of Total	100.0%	100.0%
Total		Count	30	30
		% of Total	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.[a]		
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	30		

a. No statistics are computed because Ossicles - Preop and Ossicles - Postop are constants.

b. Computed only for a PxP table, where P must be greater than 1.

Crosstabs

Jugular Bulb - Preop * Jugular Bulb - intraopCrosstabulation

			Jugular Bulb - intraop		
			Normal	Abnormal	Total
Jugular Bulb - Preop	Normal	Count	29	0	29
		% of Total	96.7%	.0%	96.7%
	Abnormal	Count	0	1	1
		% of Total	.0%	3.3%	3.3%
Total		Count	29	1	30
		% of Total	96.7%	3.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	30.000[b]	1	.000		
Continuity Correction [a]	6.992	1	.008		
Likelihood Ratio	8.769	1	.003		
Fisher's Exact Test				.033	.033
Linear-by-Linear Association	29.000	1	.000		
McNemar Test				1.000[c]	
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 3 cells (75.0%) have expected count less than 5. The minimum expected count is .03.

c. Binomial distribution used.

Crosstabs

Cochlear Turn's - Preop * Cochlear Turn's - intraop Crosstabulation

			Cochlear Turn's - intraop		
			Normal	Abnormal	Total
Cochlear Turn's - Preop	Normal	Count	29	0	29
		% of Total	96.7%	.0%	96.7%
	Abnormal	Count	0	1	1
		% of Total	.0%	3.3%	3.3%
Total		Count	29	1	30
		% of Total	96.7%	3.3%	100.0%

CROSSTABS

Warnings

No measures of association are computed for the crosstabulation of Cochlear Nerve - Preop * Cochlear Nerve - Postop. At least one variable in each 2-way table upon which measures of association are computed is a constant.

Cochlear Nerve - Preop * Cochlear Nerve -intraop Crosstabulation

			Cochlear Nerve - intraop	
			Normal	Total
Cochlear Nerve - Preop	Normal	Count	30	30
		% of Total	100.0%	100.0%
Total		Count	30	30
		% of Total	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.[a]		
McNemar-Bowker Test	.	.	.[b]
N of Valid Cases	30		

a. No statistics are computed because Cochlear Nerve - Preop and Cochlear Nerve - Postop are constants.

b. Computed only for a PxP table, where P must be greater than 1.

CROSSTABS

SEX * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Sex	Male	Count	7	8	15
		% within Group	38.9%	66.7%	50.0%
	Female	Count	11	4	15
		% within Group	61.1%	33.3%	50.0%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.222[b]	1	.136		
Continuity Correction[a]	1.250	1	.264		
Likelihood Ratio	2.256	1	.133		
Fisher's Exact Test				.264	.132
Linear-by-Linear Association	2.148	1	.143		
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.00.

Facial Nerve - Preop * Group

Crosstab

		Group		
		Cochleostamy	Round Window	Total
Facial Nerve - Preop Normal	Count	18	12	30
	% within Group	100.0%	100.0%	100.0%
Total	Count	18	12	30
	% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Facial Nerve - Preop is a constant.

OSSICLES - PREOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Ossicles - Preop	Normal	Count	18	12	30
		% within Group	100.0%	100.0%	100.0%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Ossicles - Preop is a constant.

JUGULAR BULB - PREOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Jugular Bulb - Preop	Normal	Count	17	12	29
		% within Group	94.4%	100.0%	96.7%
	Abnormal	Count	1	0	1
		% within Group	5.6%	.0%	3.3%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction[a]	.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fisher's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

COCHLEAR TURN'S - PREOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Cochlear Turn's - Preop	Normal	Count	17	12	29
		% within Group	94.4%	100.0%	96.7%
	Abnormal	Count	1	0	1
		% within Group	5.6%	.0%	3.3%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction[a]	.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fisher's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

COCHLEAR NERVE - PREOP * GROUP

Crosstab

		Group		
		Cochleostamy	Round Window	Total
Cochlear Nerve - Preop	Normal Count	18	12	30
	% within Group	100.0%	100.0%	100.0%
Total	Count	18	12	30
	% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Cochlear Nerve - Preop is a constant.

FACIAL NERVE - INTRAOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Facial Nerve -intraop	Normal	Count	17	12	29
		% within Group	94.4%	100.0%	96.7%
	Abnormal	Count	1	0	1
		% within Group	5.6%	.0%	3.3%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction[a]	.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fisher's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

OSSICLES - INTRAOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Ossicles - intraop	Normal	Count	18	12	30
		% within Group	100.0%	100.0%	100.0%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Ossicles - Postop is a constant.

JUGULAR BULB - INTRAOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Jugular Bulb -intraop	Normal	Count	17	12	29
		% within Group	94.4%	100.0%	96.7%
	Abnormal	Count	1	0	1
		% within Group	5.6%	.0%	3.3%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction[a]	.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fisher's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

COCHLEAR TURN'S - INTRAOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Cochlear Turn's - intraop	Normal	Count	17	12	29
		% within Group	94.4%	100.0%	96.7%
	Abnormal	Count	1	0	1
		% within Group	5.6%	.0%	3.3%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.690[b]	1	.406		
Continuity Correction[a]	.000	1	1.000		
Likelihood Ratio	1.045	1	.307		
Fisher's Exact Test				1.000	.600
Linear-by-Linear Association	.667	1	.414		
N of Valid Cases	30				

a. Computed only for a 2x2 table

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

COCHLEAR NERVE - INTRAOP * GROUP

Crosstab

			Group		
			Cochleostamy	Round Window	Total
Cochlear Nerve -intraop	Normal	Count	18	12	30
		% within Group	100.0%	100.0%	100.0%
Total		Count	18	12	30
		% within Group	100.0%	100.0%	100.0%

Chi-Square Tests

	Value
Pearson Chi-Square	.[a]
N of Valid Cases	30

a. No statistics are computed because Cochlear Nerve - Postop is a constant.

INTERPRETATION OF RESULTS

A total of 30 patients were selected for our study. All patients had congenital sensorineural hearing loss between the ages of one to six years underwent cochlear implantation. The study group consists of 15 male and 15 female patients. Out of 30 patients, 1 patient had rotated cochlea, enlarged vestibular aqueduct and high jugular bulb in preoperative radiological study. All the 30 patients the facial nerve course, ossicular status and cochlear nerve are anatomically normal in radiological studies.

Out of 30 patients 12 patients underwent round window insertion of electrodes. 18 patients underwent traditional cochleastomy with electrode insertion. 7 males and 11 females underwent cochleastomy technique. 8 males and 4 females underwent round window technique.

Out of 30 patients, 29 patients cochlear implantation was done through facial recess approach. 1 patient underwent canal wall down approach with blind sac closure.

Facial nerve course in all the 30 patients was radiologically normal but intraoperatively we found anteriorly displaced facial nerve in one patient.

In our study, except facial nerve, all other findings in pre operative radiological findings correlate with intraoperative findings.

DISCUSSION

In our study, two imaging modalities, HRCT temporal bone and MRI brain with cochlea are performed. This study shows HRCT scan can outline the bony border of malformed labyrinth, ossicles, jugular bulb and facial nerve course. MRI provides additional information in the preoperative work up of patients with congenital sensorineural hearing loss. The detailed imaging of the normal cochlea and the malformed cochlea are needed for proper insertion of the electrode array of the cochlear implantation. This can be visualized with MRI scan in T2 weighted images. The diameter of the internal auditory canal (2-2.5mm), cochlear nerve course and auditory cortex of brain clearly visualized in MRI scan.

The importance of HRCT scan to study the temporal bone, the surgeon can decide on the direction of electrode array to minimize the risk of misplacement and assessing the malformation preoperatively and minimizing the trauma to vital structures. Implantation of the cochlear implant requires the knowledge about the anatomical structures and its variants in the temporal bone.

The most important finding of our study, MRI scan allows full appreciation of the anatomy of the cochlear nerve within the IAC of children with congenital sensorineural hearing loss. A contraindication for cochlear implantation is a missing or ill defined cochlear nerve as this nerve is necessary to conduct the cochlear implant impulses.

Evoked potential may be used to study the function and condtion of the nerve in a clinical setting. A positive brain stem evoked potential confirms a functional nerve but a negative test does not differentiate from a damaged, undeveloped nerve or normal nerve.

Our study shows that imaging studies in congenital sensorineural hearing loss patients should not only focus just on the cochlear nerve or cochlea. One of our patients demonstrates multiple anomalies.

In patients with cochleovestibular malformation should always anticipate aberrant course or shape of the facial nerve.

Preoperative radiological imaging of temporal bone and brain help in determining the side of cochlear implantation and surgical approaches for cochlear implantation.

PREVIOUS STUDIES

Jae Jin Song et al, seoul – july 2012

His study included 972 cases from 1988 to 2009. Out of 972 cases only seven had preoperative cochlear malformations and aberrant facial nerve course. Out of these seven cases, 4 had an anteriorly placed vertical segment of the facial nerve, 2 had bifurcated facial nerve and one had inferiorly placed horizontal segment. These findings correlate with intraoperative findings.

Lima junior L R et al- Brazil, May 2008

His study included 100 patients. In 67 patients underwent CT and MRI, 33 patients underwent CT only. In HRCT of 33 patients, 23 patients had radiologically similar findings to intraoperative findings. MRI and HRCT of 67 patients, 54 had radiologically similar findings to introperative findings.

- CT only
- Accuracy- 69.69%
- Sensitivity- 36.36%
- Specificity- 86.36%
- Positive predictive value- 57.14%
- Negative predictive value- 73.07%

- CT & MRI
- Accuracy- 80.59%
- Sensitivity- 38.46%
- Specificity- 90.74%
- Positive predictive value- 50.00%
- Negative predictive value- 85.96%

CONCLUSION

Preoperative imaging before cochlear implantation surgery is important evaluation but should be done with ideal standards. This helps in selecting patients for cochlear implant surgery and also for preparing surgeons to anticipate complications and the best approach to avoid them. Full electrode insertion was possible in all patients with radiological absence of preoperative complications. Our study demonstrated that preoperative HRCT and MRI together is more accurate in detecting cochlear malformations, ossicles, jugular bulb and cochlear nerve.

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INFORMATION SHEET

We are conducting a retrospective and prospective study on **"Pre-Operative Radiological Evaluation of temporal bone in patient undergoing cochlear implant and correlate with intra-operative findings"** Review on efficacy of radiological evaluation at the Upgraded institute of Otorhinolaryngology, Madras Medical College and Rajiv Gandhi Govt. General Hospital, Chennai- 600 003.

- In this study, you should take HRCT temporal bone and cochlea, MRI brain free of cost in this institution. Operative procedure are normal and routine one. No major complications expected.

- Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time. Your decision will not result in any loss or benefits to which you are otherwise entitled.

- The results of the special study may be intimidated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management of treatment.

Signature of the Investigator **Signature of the Parent/Guardian**

Date:

PATIENT CONSENT FORM

Study Title: A retrospective and prospective study on "**Pre-Operative Radiological Evaluation of temporal bone in patient undergoing cochlear implant and correlate with intra-operative findings**" Review on Efficacy of Radiological Evaluation..

Study Centre: Upgraded Institute of Otorhinolaryngology, Madras Medical College, Rajiv Gandhi Govt. General Hospital, Chennai- 600 003.

Participant Name: Age: Sex: I.P. No:

I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask the question and all my questions and doubts have been answered to my satisfaction.

I have been explained about the pitfall in the procedure. I have been explained about the safety, advantage and disadvantage of the technique.

I understand that my child (son/daughter) participation in the study is voluntary and that I am free to withdraw at any time without giving any reason.

I understand that investigator, regulatory authorities and the ethics committee will not need my permission to look at my child health records both in respective to current study and any further research that may be conducted in relation to it, even if I withdraw from the study. I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from the study.

Time:

Date: Signature/Thumb impression of Parent/Guardian

Place: Parent's Name:

Signature of the investigator:

Name of the Investigator"

ஆய்வு தகவல் தாள்

ஆராய்ச்சி தலைப்பு : "கேள்வி நரம்பு குறைபாடு உள்ள குழந்தைகளுக்கு செயற்கை நத்தை சுருளை பொருத்துவதற்கு முன்பு எடுக்கும் ஸ்கேன்களை, பொறுத்தும்போது ஒப்பிட்டுப் பார்க்கும் ஆய்வு"

சென்னை ராஜீவ்காந்தி அரசு மருத்துவமனைக்கு வரும் கேள்வி நரம்பு குறைபாடு (SNHL) அதிகமாகவும் மற்றும் மிக அதிகமாகவும் உள்ள 1 வயது முதல் 6 வயதுக்குட்பட்ட குழந்தைகளுக்கு, செயற்கை நத்தை சுருளை (Cochlear Implant) பொருத்துவதற்கு முன்பு எடுக்கும் ஸ்கேன்களை (HRCT Temporal Bone & Cochlea and MRI Brain with Cochlear Nerve) அறுவை சிகிச்சை செய்து கருவியை பொருத்தும்போது உள்ள கண்டுபிடித்தல்களை ஒப்பிட்டுப் பார்த்து இதன்மூலம் ஸ்கேன்கள் (HRCT Temporal Bone & Cochlea and MRI Brain with Cochlear Nerve) எந்த அளவுக்கு கருவி பொருத்துவதற்கு உபயோகமாக இருக்கிறது என்பதை பற்றிய ஆராய்ச்சியாகும்.

உங்கள் குழந்தை(மகன்/மகள்) இந்த ஆராய்ச்சியில் பங்கேற்க நாங்கள் விரும்புகிறோம்.

இந்த ஆராய்ச்சியின் முடிவுகளை அல்லது கருத்துக்களை வெளியிடும்போதோ அல்லது ஆராய்ச்சியின்போதோ உங்கள் குழந்தையின் பெயரையோ அல்லது அடையாளங்களையோ வெளியிட மாட்டோம் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

இந்த ஆராய்ச்சியில் பங்கேற்பது தங்களுடைய விருப்பத்தின் பேரில்தான் இருக்கிறது. மேலும் நீங்கள் எந்நேரமும் இந்த ஆராய்ச்சியிலிருந்து பின்வாங்கலாம் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

இந்த ஆராய்ச்சியின் முடிவுகளை ஆராய்ச்சியின்போது அல்லது ஆராய்ச்சியின் முடிவின்போது தங்களுக்கு அறிவிக்கப்படும் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

ஆராய்ச்சியாளர் கையொப்பம் **பங்கேற்பாளரின் பெற்றோர் கையொப்பம்**

தேதி:

சுய ஒப்புதல் படிவம்

ஆய்வு செய்யப்படும் தலைப்பு

"கேள்வி நரம்பு குறைபாடு உள்ள குழந்தைகளுக்கு செயற்கை நத்தை சுருளை பொருத்துவதற்கு முன்பு எடுக்கும் ஸ்கேன்களை, பொறுத்தும்போது ஒப்பிட்டுப் பார்க்கும் ஆய்வு"

ஆராய்ச்சி நிலையம் : ராஜீவ்காந்தி அரசு பொது மருத்துவமனை,
சென்னை மருத்துவ கல்லூரி,
சென்னை-600 003.

பங்கு பெறுபவரின் பெயர் :

பங்கு பெறுபவரின் எண் :

பங்கு பெறுபவர் இதனை (✓) குறிக்கவும்

மேலே குறிப்பிட்டுள்ள மருத்துவ ஆய்வின் விவரங்கள் எனக்கு விளக்கப்பட்டது. என்னுடைய சந்தேகங்களை கேட்கவும், அதற்கான தகுந்த விளக்கங்களை பெறவும் வாய்ப்பளிக்கப்பட்டுள்ளது. ☐

நான் என் குழந்தையை இவ்வாய்வில் தன்னிச்சையாகத்தான் பங்கேற்க வைக்கிறேன். எந்த காரணத்தினாலோ எந்த கட்டத்திலும் எந்த சட்ட சிக்கலுக்கும் உட்படாமல் நான் இவ்வாய்வில் இருந்து விலகி கொள்ளலாம் என அறிந்து கொண்டேன். ☐

இந்த ஆய்வு சம்பந்தமாகவோ, இதை சார்ந்த மேலும் ஆய்வு மேற்கொள்ளும்போதும் இந்த ஆய்வில் பங்குபெறும் மருத்துவர் என் குழந்தையின் மருத்துவ அறிக்கைகளை பார்ப்பதற்கு என் அனுமதி தேவையில்லை என அறிந்து கொள்கிறேன். என் குழந்தை ஆய்வில் இருந்து விலகிகொண்டாலும் இது பொருந்தும் என அறிகிறேன். ☐

இந்த ஆய்வின் மூலம் கிடைக்கும் தகவலையோ, முடிவுகளையும் மற்றும் சிகிச்சை தொடர்பான தகவல்களையும் மருத்துவர் மேற்கொள்ளும் ஆய்வில் பயன்படுத்திக் கொள்ளவும் அதை பிரசுரிக்கவும் என் முழு மனதுடன் சம்மதிக்கிறேன். ☐

என் குழந்தை இந்த ஆய்வில் பங்குகொள்ள ஒப்புக்கொள்கிறேன். எனக்கு கொடுக்கப்பட்ட அறிவுரைகளின்படி நடந்து கொள்வதுடன் இந்த ஆய்வை மேற்கொள்ளும் மருத்துவ அணிக்கு உண்மையுடன் இருப்பேன் என்றும் உறுதியளிக்கிறேன். என் குழந்தையின் உடல் நலம் பாதிக்கப்பட்டாலோ அல்லது எதிர்பாராத வழக்கத்திற்கு மாறான நோய்குறி தென்பட்டாலோ உடனே அதை மருத்துவ அணியிடம் தெரிவிப்பேன் என உறுதியளிக்கிறேன். ☐

பங்கேற்பவரின் பெற்றோர் கையொப்பம் ..... இடம்..... தேதி .....

கட்டைவிரல் ரேகை

பங்கேற்பவரின் பெயர் மற்றும் விலாசம்.....

ஆய்வாளரின் கையொப்பம் ..... இடம்..... தேதி .....

ஆய்வாளரின் பெயர் .....

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
Telephone No. 044 25305301
Fax : 044 25363970

CERTIFICATE OF APPROVAL

To
Dr. P.SENGOTTUVELU
Postgraduate MS (ENT),
Madras Medical College,
Chennai – 600 003.

Dear Dr. P.SENGOTTUVELU,

The Institutional Ethics Committee has considered your request and approved your study titled " **PRE-OPERATIVE RADIOLOGICAL EVALUATION OF TEMPORAL BONE IN PATIENT UNDERGOING COCHLEAR IMPLANT AND CORRELATE WITH INTRA OPERATIVE FINDINGS REVIEW ON EFFICACY OF RADIOLOGICAL EVALUATION BY RETROSPECTIVE & PROSPECTIVE STUDY No. 28082014.**

The following members of Ethics Committee were present in the meeting held on **05.08.2014** conducted at Madras Medical College, Chennai-3.

1.	Dr.C.Rajendran, M.D.,	: Chairperson
2.	Dr.R.Vimala, M.D., Dean, MMC, Ch-3	: Deputy Chairperson
3.	Prof.B.Kalaiselvi, M.D., Vice-Principal, MMC, Ch-3	: Member Secretary
4.	Prof.R.Nandhini, M.D., Inst.of Pharmacol ogy, MMC	: Member
5.	Dr.G.Muralidharan, Director Incharge, Inst.of Surgery	: Member
6.	Prof.K.Ramadevi, Director i/c, Inst.of Biochemistry, MMC	: Member
7.	Prof.Saraswathy, M.D., Director, Pathology, MMC, Ch-3	: Member
8.	Prof.Tito, M.D., Director i/c, Inst.of Internal Medicine, MMC	: Member
9.	Thiru S.Rameshkumar, Administrative Officer	: Lay Person
10.	Thiru S.Govindasamy, B.A., B.L.,	: Lawyer
11.	Tmt.Arnold Saulina, M.A., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.
The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

MASTER CHART

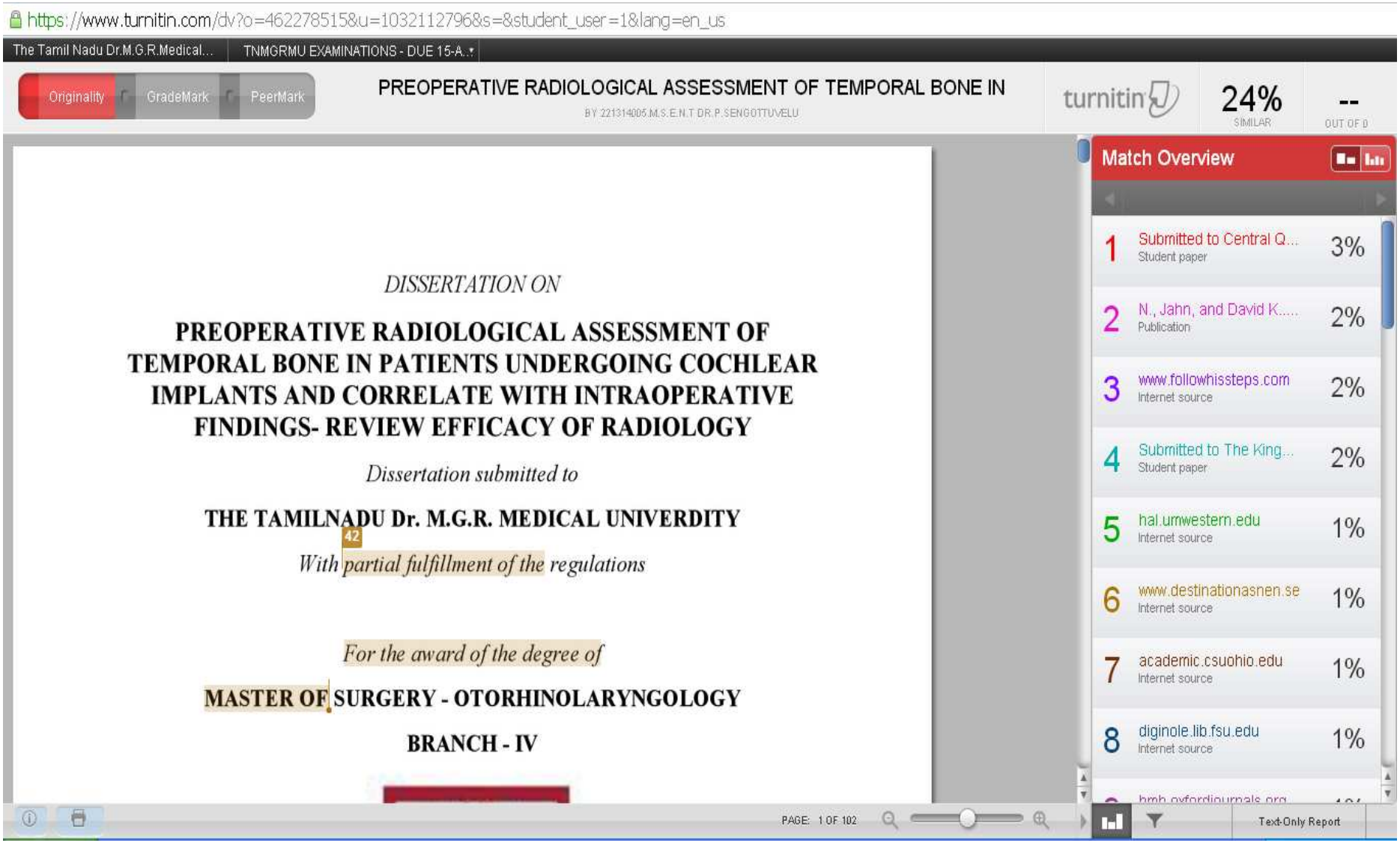
S.No	Name	Age	Sex	Pre-Operative findings in Radiology (HRCT & MRI)					IT	Intra-Operative findings				
				FN	OSSI	JB	CT	CN		FN	OSSI	JB	CT	CN
1.	Kaviya	3	F	N	N	N	N	N	RW	S	S	S	S	S
2.	Ashwanth	4	M	N	N	N	N	N	RW	S	S	S	S	S
3.	Mukunthan	3	M	N	N	N	N	N	RW	S	S	S	S	S
4.	Madesh	2	M	N	N	N	N	N	C	S	S	S	S	S
5.	Hemalatha	6	F	N	N	N	N	N	RW	S	S	S	S	S
6.	Vishnu	5	M	N	N	N	N	N	RW	S	S	S	S	S
7.	Pugal	2	M	N	N	N	N	N	RW	S	S	S	S	S
8.	Kalpana	3	F	N	N	N	N	N	C	S	S	S	S	S
9.	Saravanan	5	M	N	N	N	N	N	RW	S	S	S	S	S
10.	Abinesh	5	M	N	N	N	N	N	RW	S	S	S	S	S
11.	Jeebika	5	F	N	N	N	N	N	C	S	S	S	S	S
12.	Vikram	4	M	N	N	Ab	Ab	N	C	Ab	B	S	S	B
13.	Asma Parveen	5	F	N	N	N	N	N	C	S	S	S	S	S
14.	Hasanidos	5	M	N	N	N	N	N	C	S	S	S	S	S
15.	Ayisha Banu	5	F	N	N	N	N	N	C	S	S	S	S	S
16.	Hasina	5	F	N	N	N	N	N	C	S	S	S	S	S
17.	Praveena	2	F	N	N	N	N	N	C	S	S	S	S	S
18.	Mugammed Salem	4	M	N	N	N	N	N	RW	S	S	S	S	S
19.	Dinesh	6	M	N	N	N	N	N	C	S	S	S	S	S
20.	Ponmozhi	5	F	N	N	N	N	N	RW	S	S	S	S	S
21.	Rachel	5	F	N	N	N	N	N	C	S	S	S	S	S
22.	Sanjay	6	M	N	N	N	N	N	C	S	S	S	S	S
23.	Sivasakthi	6	F	N	N	N	N	N	C	S	S	S	S	S
24.	Namira Banu	5	F	N	N	N	N	N	C	S	S	S	S	S
25.	Sundarsan	6	M	N	N	N	N	N	C	S	S	S	S	S
26.	Sanjay	3	M	N	N	N	N	N	C	S	S	S	S	S
27.	Vijay Shri	6	F	N	N	N	N	N	RW	S	S	S	S	S
28.	Kabilan	6	M	N	N	N	N	N	RW	S	S	S	S	S
29.	Abirami	6	F	N	N	N	N	N	C	S	S	S	S	S
30.	Jayasurya Kala	5	F	N	N	N	N	N	C	S	S	S	S	S

FN	Facial Nervee
CN	Cochlear Nerve
N	Normal

OSSI	Ossicles
IT	Insertion Technique
S	Same

JB	Jugular bulb
C	Cochleostomy
Ab	Abnormal

CT	Cochlear turns
RW	Round Window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Dissertation submitted to
THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERDITY
With partial fulfillment of the regulations
For the award of the degree of
MASTER OF SURGERY - OTORHINOLARYNGOLOGY
BRANCH - IV
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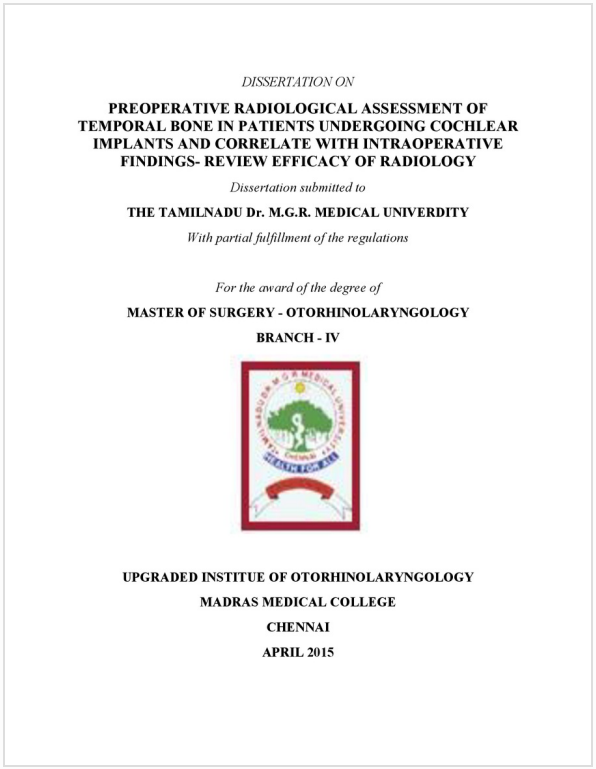

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